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ABSTRACT

Provided are papers and speeches presented at the Seventh Annual American Association for the Advancement of Science (AAAS) Colloquium on Research and Development (R&D) Policy. Presenters included key representatives of Congress, the Reagan administration, government agencies, and those involved in industry and university R&D. Major areas addressed during the colloquium included: (1) Federal R&D: budgets, policies, outlooks; (2) changing climate for industrial R&D; (3) agency perspectives on R&D in the FY 1983 budget (including reports from the Department of Defense, Department of Energy, National Aeronautics and Space Administration, National Institutes of Health, and the National Science Foundation); and (4) R&D in the FY 1983 Budget: Impacts on Institutions. Addresses given by Margaret M. Heckler (U.S. House of Representatives), Paul E. Tsongas (U.S. Senate), and Harrison Schmitt (U.S. Senate) are also included. Biographical statements on presenters and a complete list of colloquium participants are provided in appendices. (JN)

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AAAS Committee on Science, Engineering and Public Policy

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Impact and Challenge R&D in the FY 1983 Budget

Colloquium Proceedings 23-24 June 1982

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Edited by
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Acknowledgments

The editors would like to express their appreciation to many people who assisted in the preparation of these proceedings. Colloquium speakers generously contributed their time and thoughts both to the meeting sessions and to the subsequent compilation of this report. A special note of thanks should go to Steven Buyske, summer intern at AAAS, for his editorial efforts. Thanks are due also to Arlene Miller, Adele Jenkins, Kim Walker, Esther Phillips, Judith Katzoff, Bea Bagley, Joellen Fritsche, Nancy van Ackern and Susan Cherry for their help in assembling this volume.

Introduction

This volume presents the proceedings of the Seventh Annual AAAS Colloquium on R&D Policy, which was held at the Shoreham Hotel in Washington, D.C. on 23-24 June 1982.

Although the turmoil that characterized the budget process during the first year of the Reagan Administration had subsided somewhat, the pressure to reduce federal expenditures continued and Congressional budget politics remained (and remains) volatile. These influences, together with a growing sensitivity to the importance of industrial R&D and science and engineering education, framed two days of intense discussions among approximately 400 participants -- leaders of the scientific and engineering communities from the academic world, industry, and government; policymakers from the executive and legislative branches of the federal government, as well as state and local governments; and representatives of the media.

Research and Development: AAAS Report VII, by Willis H. Shapley, Albert H. Teich, and Jill P. Weinberg, was distributed in advance of the Colloquium to speakers and pre-registered participants, and served to focus discussion. Readers of these Proceedings who have not read AAAS Report VII would be well advised to obtain a copy, for it provides the basic data and analysis of R&D in the FY 1983 federal budget on which many of the papers contained herein are based.*

Most of the papers included in the Proceedings are based on advance texts provided by the speakers; a number, however, were prepared from tape recordings made at the meeting. All have been edited for clarity and reviewed by the speakers. Brief summaries of the "agency perspectives" sessions are also included. These were informal, small-group sessions at which top officials of five R&D-intensive federal agencies answered questions from members of the audience. The summaries were prepared from notes and tape recordings and have not been reviewed by the speakers.

*Research and Development: AAAS Report VII is available from the AAAS Sales Office, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005. The price is $8.00.

The AAAS R&D Budget and Policy Project, of which the Colloquium is one element, is conducted under the guidance of the Committee on Science, Engineering and Public Policy and the oversight of the AAAS Board of Directors. A grant from the Alfred P. Sloan Foundation provided financial support during its first several years. A growing number of AAAS's affiliated societies have collaborated in the budget project through a preliminary analysis of the President's budget proposals and a review of congressional action on R&D in the budget. Their efforts will take on even greater importance and visibility next year when the Colloquium moves from its traditional June date to late March.

William D. Carey
Executive Officer
AAAS

August 1982

Agenda for the Colloquium

Wednesday, 23 June

8:45 a.m. **Welcome**

Blue Room
E. Margaret Burbidge, *President, AAAS;* and *Director, Center for Astrophysics and Space Sciences, University of California, San Diego*

Conference Overview

Willis H. Shapley, *Consultant to AAAS for the R&D Budget Analysis Project*

Albert H. Teich, *Manager, Science Policy Studies, AAAS*

9:15 a.m. **Federal R&D: Budgets, Policies, Outlooks**

Blue Room
Moderator:
J. Thomas Ratchford, *Associate Executive Officer, AAAS*

Speakers:

George A. Keyworth, II, *Director, Office of Science and Technology Policy, Executive Office of the President*

Michael L. Telson, *Professional Staff Member, Committee on the Budget, U.S. House of Representatives*

Frederick N. Khedouri, *Associate Director for Natural Resources, Energy and Science, Office of Management and Budget*

Frank Press, *President, National Academy of Sciences*

12:30 p.m. **Luncheon**

Ambassador Room
Presiding:
William G. Wells, Jr., *Head, Office of Public Sector Programs, AAAS*

Address:

Margaret M. Heckler, *U.S. House of Representatives*

2:15 p.m. **The Changing Climate for Industrial R&D**

Blue Room
Moderator:
Robert L. Stern, *Senior Associate, Institute of Public Administration*

Speakers:

Daniel Adams, *Chairman, Advanced Genetic Sciences*

George R. White, *Vice President for Research, Development and Engineering, Xerox Corporation*

D.V. D'Arbeloff, *Chairman, Board of Directors;* and *Chief Executive Officer, Millipore Corporation*

Arden Bement, *Vice President for Technical Resources, TRW, Inc.*

4:00 p.m. **Agency Perspectives on R&D in the FY 1983 Budget**

Board Room
Department of Defense

Moderator:

Rodney W. Nichols, *Chairman, AAAS Committee on Science, Arms Control and National Security;* and *Executive Vice President, The Rockefeller University*

Speaker:
Leo Young, *Director of Research and Technical Information, Department of Defense*

Forum Room — **Department of Energy**
Moderator:
Shirley M. Malcom, *Head, Office of Opportunities in Science, AAAS*
Speaker:
Joel A. Snow, *Senior Science Associate, Office of Energy Research, Department of Energy*

Directors Room — **National Aeronautics and Space Administration**
Moderator:
Peter B. Boyce, *Executive Officer, American Astronomical Society*
Speaker:
Robert F. Allnutt, *Associate Deputy Administrator, National Aeronautics and Space Administration*

Club B Room — **National Institutes of Health**
Moderator:
Virginia Holt, *Office of Scientific Affairs, American Psychological Association*
Speaker:
Thomas E. Malone, *Deputy Director, National Institutes of Health*

Tudor Room — **National Science Foundation**
Moderator:
Le-Nhung McLeland, *Department of Public Affairs, American Chemical Society*
Speaker:
James M. McCullough, *Deputy Director, Office of Planning and Resources Management, National Science Foundation*

5:45 p.m. Blue Room — **Reception**

7:00 p.m. Blue Room — **Banquet**
Presiding:
D. Allan Bromley, *Chairman, AAAS Board of Directors;* and *Henry Ford II Professor of Physics, Yale University*
Address:
Paul E. Tsongas, *U.S. Senate*

Thursday, 24 June

9:00 a.m. — **R&D in the FY 1983 Budget: Impacts on Institutions**

Blue Room

Moderator:

Gail Pesyna, *Member, AAAS Committee on Science, Engineering and Public Policy;* and *Program Specialist, New Business Programs, E. I. du Pont de Nemours & Co.*

Speakers:

David V. Ragone, *President, Case Western Reserve University*

Martin Goland, *President, Southwest Research Institute*

David Shirley, *Director, Lawrence Berkeley Laboratory*

12:15 — **Cash Bar Reception**

Bird Cage Walk

12:45 p.m. — **Luncheon**

Diplomat Room

Presiding:

Ray Thornton, *Chairman, AAAS Committee on Science, Engineering and Public Policy;* and *President, Arkansas State University*

Address:

Harrison (Jack) Schmitt, *U.S. Senate*

Concluding Remarks:

William D. Carey, *Executive Officer, AAAS*

WELCOME

E. Margaret Burbidge *(President, AAAS; and Director, Center for Astrophysics and Space Sciences, University of California, San Diego)*

CONFERENCE OVERVIEW

Willis H. Shapley *(Consultant to AAAS for the R&D Budget Analysis Project)*

Albert H. Teich *(Manager, Science Policy Studies, AAAS)*

Welcome

E. Margaret Burbidge

I am very pleased to welcome all of you to the Seventh Annual Colloquium on R&D Policy -- the seventh in a series of what I believe to be increasingly important opportunities to discuss the current state, the immediate future, and the long-term future of the nation's research and development effort.

This Colloquium is intended not only to provide an opportunity to hear from key representatives of Congress, the administration, government agencies, and those involved in R&D in industry and in the universities; it is intended also, and very importantly, to be a forum for the exchange of ideas, concerns, opinions, and information during the question-and-answer and discussion periods following the presentations by the speakers.

The basic document that the AAAS puts out on this subject is the annual Research and Development Report. It assembles, analyzes, and discusses the R&D outlook from the perspective of current national philosophical, as well as practical (i.e., budgetary), support.

This year's excellent report, number VII in the series, is entitled "Federal Budget -- FY 1983 -- Impact and Challenge." It has been prepared for the AAAS Committee on Science, Engineering, and Public Policy by Willis Shapley, a consultant to AAAS, and AAAS staff members Albert Teich and Jill Weinberg. All of you have a copy of this book, for the preparation of which the AAAS owes a huge vote of thanks to its authors and to the contributors of material used in it. I understand that this annual report has become easily the most-read document on the subject of R&D effort not only in the nation's capital, but everywhere where research and development are carried on and where the impacts of budgetary policy are felt.

The report was, of course, based on the President's budget of February 1982, not on the very recent amended

budgets hammered out by the House and Senate after four months of effort. Since I am absolutely non-expert in economic theory and its large-scale practice, my mind has been turning to possible analogues to the budgetary process itself and to its impacts on R&D, analogues familiar to me in physics.

As I thought about the horrendous switch from this administration's earlier expectations for a nearly balanced federal budget, to the enormous projected deficit for FY 1983 and the continuing deficits projected for the next five years, and as I read Chapter 4 in the Shapley, Teich and Weinberg report -- a new chapter on the impacts of tightening federal budgets -- the analogue in physics that sprang to mind immediately is Catastrophe Theory!

Please don't be alarmed -- I'm not implying that the Nation faces imminent disaster in its activities in science, engineering, and technology -- quite the contrary. As Allan Bromley said in his opening speech to this Colloquium last year, and as I reiterated in testimony to Congress in April on the NSF budget, we have a large head start in the world-wide science and technology effort, but we are seeing erosion in that lead, and it is even necessary, like Alice Through the Looking Glass, to run very hard to stay in the same place.

In referring to Catastrophe Theory I mean the technical term in physics which describes the behavior of physical quantities when the relationships between them don't run smoothly. When such relationships between physical variables, and the compounded effect of their interactions, can lead to wildly different end points, and when the switch from one end state to another can occur if there is even a minuscule change in one or more of the variables, this is a classical case for the application of the mathematics of Catastrophe Theory.

While the theory itself is quite technical in the mathematics it uses, some very homely examples of its effects can be quite easily demonstrated. Last summer I attended a marvelous public lecture given by Brian Pippard, the Cavendish Professor of Physics at Cambridge University, England. It was entitled "Instability and Chaos -- Physical Models of Everyday Life." The program announcement for the lecture stated that Pippard would present demonstrations of various types of instability, including those leading to "chaotic" behavior, and that he would discuss whether these could usefully serve as models or warnings in the conduct of everyday life and of government.

As the audience assembled, we saw that the entire stage was filled with wonderful gadgets and experiments, contrived from elementary laboratory materials: water wheels connected with tipping channels of flowing water, mechanical structures of weird and delicate shapes, electrical and optical gadgets, all of which were designed to flip from one configuration to another at the least touch of Brian Pippard's finger, or even on their own as a result of very small natural perturbations. He proceeded to link all these demonstrations with events that occur in everyday life, and to make analogies with the drastic long-term consequences of perturbations in the supply of funding and resources for science and education!

Such consequences in our own national scene are explored in Chapter 4 of the R&D Report VII. They include, of course, the impact of budgetary cuts on education in science, not only as a 20-year process for producing our leaders and innovators in scientific research in all fields, but as the means by which we ensure that the general public, and especially our leaders who are not specifically trained in science, have the general background education to make them literate in an increasingly technologically-oriented environment.

Cutbacks that lead to the breakup of scientific teams in universities and other institutions obviously can destroy or devastate long-range research projects. A general malaise in the form of loss of faith, loss of hope, loss of expectations, points even the brightest young people toward short-term, quick-reward research, and away from goals that may be far more valuable but may take years to achieve. We need to transmit the importance of these long-term goals to the general public.

We need also to emphasize in the strongest terms that "R" cannot be separated from "D", any more than science education at the higher levels can be separated from basic research. One might invert the "R&D" and talk about Discovery and Reward!

It has been said many times by many people that today's basic research is the commonplace technology years or decades downstream. If I may cite just one example, again from physics, lasers and masers are commonplace words now, but when Einstein propounded his theory of radiation and the Einstein A and B coefficients, who would have foreseen then that those studies early in the 20th century foreshadowed the Nobel Prize-winning discovery of masers and lasers so many decades later?

Let me reiterate that we hope this Colloquium will be an opportunity for discussion, interaction, and information transfer, and for making and maintaining personal contacts with all the contributors to the Colloquium. To repeat some words said by Allan Bromley a year ago: "Time and effort spent in making personal contact with your elected representatives and in acquainting them with your concerns . . . can be very effective in influencing the directions of R&D policy and support in this country."

Now, I've taken enough of your time -- let me call on Willis Shapley and Albert Teich to give you an overview of the FY 1983 budget situation and of the Conference before you.

Introduction

Willis H. Shapley

My task in the next few minutes is to summarize the situation on R&D budgets and related matters as we begin this Seventh Annual AAAS Colloquium on R&D Policy. The situation is confused and confusing. The hope is that this Colloquium -- our distinguished speakers and all of you as participants -- will give us all a clearer picture and better mutual understanding of the problems by the time we adjourn tomorrow afternoon.

The impacts and challenges of the President's FY 1983 budget as we saw them in April are summarized in our report. The cheerful yellow cover encloses a rather gloomy message.

Our overall assessment, however, is that the President's FY 1983 budget treated R&D fairly well, for the most part, given the economic exigencies and the policy orientations of the Reagan Administration. Within these policies, some fine-tuning of the amounts for R&D deserves serious consideration; some of this may be done by Congress as it acts on the details of the budget. However, there are also some big questions on the policies themselves -- defense, energy, education, public vs. private sector, and so on -- questions with major impacts on R&D which I am sure will figure prominently in the discussions today and tomorrow.

What will be the outcome in Congress? Later this morning we will have an insider's expert up-to-the-minute report on the status and prospects. As I see it, the spending levels in the conference report on the first budget resolution, if accepted by both houses, leave open the possibility that the R&D budgets finally approved by Congress could approximate closely the recommendations in the President's budget.

For budget function 250, the only category that consists entirely of R&D (NSF, DOE general science and research, NASA), the conferees have recommended exactly the same amounts as in the President's budget, as proposed by the Senate. This is preferential treatment. The House bill and the general Congressional guideline of freezing FY 1983

budgets for discretionary spending at the FY 1982 levels would have meant a cut of about 10 percent.

The totals for most of the other budget functions also seem adequate to include the amounts budgeted for R&D, except in the case of national defense, where the 3.6 percent reduction in total budget authority could mean a cut of as much as $1 billion in the $4.4 billion increase recommended in the budget for national defense R&D.

Regardless of what happens in the first budget resolution, the final outcome will depend on (1) how R&D is treated by Congress in the detailed authorization and appropriations bills, and (2) whether the appropriations bills as passed are acceptable to the President. Detailed Congressional action could produce R&D budgets that are revised, perhaps improved, versions of the President's budget. But a Presidential veto and another stand-off between the President and Congress would probably end up again this year with percentage across-the-board reductions applied indiscriminately to R&D along with other programs.

The longer-term outlook for R&D is, as our report shows, at best, bleak. Even under optimistic economic assumptions, total funding available for non-defense R&D faces a reduction in constant dollars of as much as 30 percent over the five-year period FY 1983 to FY 1987, unless continued high deficits, substantial increases in taxes, or major cut-backs in defense -- or some combination of these -- become acceptable economically and politically. The establishment of plans and priorities for federal support of R&D within a total level of resources that is declining in real terms is the single greatest challenge facing the scientific and technical leadership in the government and the scientific and technical community as a whole.

There are plenty of other challenges. I will mention only three:

1) There is the challenge to all of us to see that something, besides talk, gets done about the problems of science and engineering education at all levels. Our decentralized education system needs leadership. Who will provide it? The federal government? If not, who?

2) There is the challenge to industry to show that the U.S. private sector, in the favorable regulation and taxation

environment created by the Reagan Administration, can match the competition from other nations in innovation, i.e., in developing and marketing new and improved products and services based on advances in science and technology.

3) Closer to home -- here in Washington -- there is an urgent challenge to Congress and the Executive Branch to find ways to temper the operation of the budget process. In this year's report I was able to count 160 distinct steps in the budget process as it now "works," if that is the right word. At a minimum, a way has to be found to insulate from the hurly-burly of controversy on overall budget and fiscal policy the core of largely non-controversial functions of government for which the range of likely budget adjustments, even in the aggregate, does not have an appreciable impact on the size of the deficit, the level of revenues, or the state of the economy. Even if much of the confusion, uncertainty, and frustration of the present budget process has to be accepted as a necessary price for resolving deep-set differences in economic and political outlooks within our constitutional framework, we should nevertheless be able to find a way to conduct important continuing activities like R&D within the framework of approved long-range plans and clearly defined fiscal envelopes, without the continual disruptions and uncertainties that characterize the present budget process.

Conference Overview

Albert H. Teich

My purpose here is simply to give you a few words about the program and to tell you a little bit about what's in store for you during the next day and a half. If you have had a chance to read through Research and Development: AAAS Report VII, you may have noticed that there is a rough parallelism between the structure of the book and the structure of the Colloquium program. I want to assure you that this is not coincidental. In fact, in preparing this book we have sought to provide a framework for the discussions that we intend to have here during the next day and a half.

You will find that much of the material that our distinguished panel will address shortly at the opening session on "Federal R&D: Budgets, Policies, Outlooks" is reflected in the substance of Chapter 1, which takes an overview of the budget situation, and Chapter 6, in which we have expanded the famous 123 steps described in the first R&D Report to 160 steps. These 160 steps represent the budget process as it is today.

In the afternoon plenary session today, in which we will discuss "The Changing Climate for Industrial R&D," we will have representatives of four rather different types of industrial firms. They range from "Fortune 500" firms such as Xerox Corporation and TRW, Inc., to smaller, more specialized outfits such as Millipore Corporation, a high technology firm, and Advanced Genetic Sciences, a new entry into the biotechnology game. These individuals will be discussing issues touched upon in Chapter 5 of the report.

Late this afternoon we will have a series of parallel, workshop-style sessions devoted to R&D budget and policy issues in five key federal agencies. Top policy-level officials of those agencies will talk briefly and then answer questions and participate in discussions with you. Those sessions have their analogues in Chapter 2 in our report in which we present somewhat more detailed analyses of agency R&D budgets than we have had in the past editions.

Finally, tomorrow morning, we will have a session on the impacts of changing R&D budget priorities on R&D institutions. To that session we have invited representatives of several key categories of R&D institutions -- universities, national laboratories, and not-for-profits. That session has its counterpart in Chapter 4 of the report, which is devoted to the impacts of tightening federal budgets.

We also have scheduled for you, as I'm sure you know, two luncheons -- one today at which Representative Margaret Heckler will speak, and one tomorrow at which Senator Harrison Schmitt will speak. Tonight there is a banquet at which Senator Paul Tsongas will speak.

We've set up this meeting in a way that, we hope, does not overload the platform with speakers. We've tried to allow enough time so that there will be an opportunity for you to ask questions of each speaker and for an interactive atmosphere to develop. We trust that you will take advantage of this and participate by asking questions and making comments.

FEDERAL R&D: BUDGETS, POLICIES, OUTLOOKS

Moderator:
J. Thomas Ratchford *(Associate Executive Officer, AAAS)*

Speakers:
George A. Keyworth, II *(Director, Office of Science and Technology Policy, Executive Office of the President)*

Michael L. Telson *(Professional Staff Member, Committee on the Budget, U.S. House of Representatives)*

Frederick N. Khedouri *(Associate Director for Natural Resources, Energy and Science, Office of Management and Budget)*

Frank Press *(President, National Academy of Sciences)*

Federal R&D: Budgets, Policies, Outlooks

Introduction

J. Thomas Ratchford

Margaret Burbidge noted in her opening remarks that this is the Seventh Annual AAAS R&D Policy Colloquium. You might say that we are a part of a young tradition -- seven years being on the margin for traditions even in America. Each year we are welcomed by the AAAS President or Board Chairman. This is followed by an overview by Willis Shapley, enriched this year by Al Teich, and concluding remarks by Bill Carey. Another tradition is this opening session, addressing budgets, policies, and outlooks. It is designed each year to provide the latest predictions of things to come -- not from Drew Pearson (those of you in my generation will remember him) but from the real horse's mouths here in Washington. They are from the White House, Congress, and, since we are who we are, the scientific community.

Regular observers of the Washington scene have witnessed many changes in the last seven years. As noted earlier, in the first Shapley report, Willis traced the budget process step by step. An update is longer and more complex and, more importantly, qualitatively different as well. We have seen the budget process evolve from straightforward authorization and appropriations acts to one dominated by budget resolutions and ascendant budget committees in the Congress.

I have had the pleasure of moderating six of the last seven opening sessions at these colloquia, and last night, in reflecting on today's topic and reviewing what had gone on before, I ran across these introductory remarks from

1980. "This year we have something different -- a Congressional budget process that, for the first time, is in danger of working. The Congressional Record reads like a soap opera, with news of proposals, rescissions, and reconciliations popping out on almost every page." Well, the budget process is working or not working depending on your point of view. In any case, it's fascinating to watch, and we shall learn more about it today.

Dr. Burbidge earlier used analogies from her chosen field of physics to aid in understanding budgetary impacts on R&D and the society which provides the financial resources for its performance and reaps the benefits of its successes. I am pleased by her analogies because they imply the political process which makes these determinations is rational. Many in the scientific and engineering communities hold otherwise. In fact, many of my colleagues in physics look with disdain on the political process and marvel that someone has not developed a simple theory which, competently applied, would remove the need for the cumbersome, irrational procedures that make up our present system. However, one can just as easily and, I believe, much more realistically conclude that the political process is the only completely rational process in our society. This is the case because only it can take into account all of the boundary conditions. Mathematicians, scientists, and engineers who use Catastrophe Theory, for example, know it is effective in solving real problems only if the boundary conditions are accurately specified.

This year our Colloquium topic is the impact of the fiscal year 1983 R&D budget on scientific and engineering institutions and the challenge before all of us to apply and use R&D resources more effectively. Our speakers are well suited to the task at hand -- to provide the intellectual and numerical framework for a day and a half of discussions of these topics. With luck, we shall distill some insights of value to us all.

George A. Keyworth, II

When Allan Bromley invited me to take part in these annual AAAS festivities, he reminded me that my first formal appearance as the President's Science Adviser was at this Colloquium a year ago. That was an event I thoroughly enjoyed -- until I started reading in the press what it was I supposedly said and what it supposedly meant. Well, let me try again -- a year older and a year wiser -- to describe the global context for science and technology in the Reagan Administration.

It's natural for anxiety to run high in Washington when there's a change in administration, and the delay in my arrival no doubt contributed a little extra to the uncertainty about the role for science and technology in our administration. I hope that by now we're all prepared to look realistically at the situation and opportunities at hand.

Today I'd like to look beyond the immediate topic of the FY 1983 R&D budget, which will no doubt be discussed by others at great length. Instead, I want to share with you some thoughts on how science and technology fit into the administration's goals for America, and to share some thoughts on what role we -- the science community -- must play in coming years.

I don't think any conference on federal R&D priorities can ignore the overriding significance of our country's economic condition. It's the dominant factor in virtually all White House deliberations on policy issues. Not only does the economy determine how much R&D the nation can pay for, but it also influences what kind of R&D we'll do. As I'll discuss, R&D are important to our immediate economic recovery and critical to our long-term health -- and the President is well aware of that.

The President has been attacking the nation's economic problems directly through a combination of fiscal policies. And in spite of all the public hand-wringing, I'm convinced that most people now recognize the inescapable truth of what must be done to restore America's luster. I think that was

demonstrated two weeks ago when the House of Representatives made some hard political choices and finally approved a responsible federal budget for fiscal year 1983.

But I don't think I'm revealing any confidential information when I say that economically this hasn't been a good year for the United States. For nearly two decades we've been living increasingly beyond our means -- or if you prefer, we've been neglecting to replenish our means to keep pace with our aspirations -- and it's finally taking a brutal toll. High inflation, higher taxes, and crippling interest rates have been eroding our ability and incentive to prepare for the future.

A whole generation in our society has literally grown up under generous government programs; to them, reductions in the rate of growth in federal spending must seem positively un-American. And actual cutbacks are almost unthinkable. Unfortunately, that has to be part of the solution to restoring health to our economy.

I don't think I have to remind you that controls on federal spending are having broad and painful effects on federal programs. For that reason the modest, but real growth slated for R&D and for basic research in the FY 1983 budget is highly significant and noteworthy. In this regard I feel compelled to get something off my chest -- and this strikes me as a good forum in which to do it. But let me get there by way of an analogy.

From the time when I was still an honest scientist, I remember a theoretical nuclear physicist who had devised a comprehensive theory of nuclear isomers. The only trouble was that his theory was increasingly assailed by the discovery of more and more examples that challenged it. In due course a final experimental finding was inconsistent with his theory. His classic response to that discovery was to say: "I like my theory. Don't encumber it with facts."

Likewise, I'm afraid, much of the science community in the past year has been obsessed with some kind of theory that the Reagan Administration was out to cut science budgets for various ideological reasons. So pervasive was that belief that the release of the proposed FY 1983 budget, with R&D getting the second largest increase of any budget function -- and in a time of severe fiscal constraints -- went virtually unnoticed. Instead of recognizing the importance placed on R&D in the budget, especially in comparison to other federal programs, like that physicist the science community has been

sticking to its bogeyman theory and was not about to encumber it with facts.

Let me give an example of the frustration my staff and I endure in this area. For ten years support for the three major Department of Energy high energy physics facilities -- SLAC, Fermilab, and Brookhaven -- has been falling behind inflation. Today they are starved into a state of near intellectual malnutrition. I posed this question to the High Energy Physics Advisory Panel, appointed by both the Department of Energy and the National Science Foundation: "What would be necessary to maintain United States leadership in high energy physics through this decade and beyond?" Following their advice, we added nearly 20 percent to the DOE high energy physics budget. We attempted to ensure that we would extract the optimum amount of physics from existing facilities and that we would posture ourselves to meet future demands for new experimental facilities. All this occurred in the midst of fiscal scrutiny that was unprecedented in recent times. Nevertheless, the only reports ensuing from this action addressed the demise of a facility to which the high energy physics community would only attach high priority if a 35 percent increase in the budget could be implemented.

Another example: We proposed another nearly 20 percent increase in the budget for space science research because we saw tremendous opportunity for a broad research program using the Space Shuttle. We emphasized the astrophysics and astronomy research programs available with the Shuttle, including the Space Telescope. At the same time, we chose to ask the planetary science community to restructure their program to provide more missions at lower cost. After all, the cost of each mission was approaching a billion dollars, equal to the budget of the entire National Science Foundation. Our objective was to sustain a vital but realistic effort in planetary research. Yet to hear the space science community, we've gutted their activities.

I would hate to conclude that the science community, which I hold in such high regard, is unable to rise above the kind of pork barrel thinking that says a program once started must continue -- and grow -- independent of scientific priorities. Unfortunately, that kind of attitude can be found all too often. Recently I found myself amidst a group of politicians addressing the role of science and technology in our future. A senator attacked the Reagan Administration's reduction of funds for windmill research at a NASA center as an example of how we were cutting basic research. Faced with

responses like these, how can we take those fresh looks at research priorities that scientists routinely do when new opportunities for more promising research come along?

Now, having delivered myself of those pent-up reactions, let me emphasize that it's important that we not let these intramural squabbles about shifts in priorities for areas of research overshadow a far more important aspect of science policy. Last year we explicitly stated our intention to move the federal government out of the areas of development and commercial demonstration activities, except where the government was the customer. But at the same time, we stated our strong commitment to the federal government's continuing responsibility for assuring a healthy basic research enterprise.

We aimed for a clear-cut -- which means predictable -- distinction between what should be public sector and what should be private sector responsibilities.

We had two goals in mind. One was to achieve what we believe is the properly limited role for the federal government, one that makes sense for a free enterprise economy. The second goal was to give some clear signals to the private sector, which has to make investment decisions based on some assurances of what markets will look like in the future. There's nothing like the hint of the government stepping into an area of research to effectively dissuade private companies from putting their own money into it.

In general we wanted to strengthen the government in those vital activities it does well -- like basic research -- and get it out of those it does poorly -- like demonstration of commercial technologies. Perhaps the latest noteworthy example of a misplaced government priority has been our support for demonstration projects in fossil and solar energy. We spent $30 billion in pursuit of programs that had no significant likelihood of helping us achieve the energy independence they were supposed to contribute to. Why did they fail? Because there was no natural market for the products of those expensive technologies. It's no wonder private industry was reluctant to invest large amounts of its own money to improve the technologies.

So what made the government take the plunge? Well, there were a lot of political and social reasons, but to my mind they were all predicated on the wishful thinking that government could somehow operate independent of market forces, that it could subsidize a technology into competitiveness. So in keeping with our policy for science

and technology, we're pulling back now, removing government from those demonstration projects that would be well within the capability of private industry to make competitive -- if a market existed. At the same time we're concentrating instead -- and at lower cost -- on continuing with the kinds of research that might eventually lead to true technological breakthroughs in energy.

This brief description of the major philosophical elements of our science policy isn't new to you, but I did want to present some specific examples of how it guided us in putting together the proposed FY 1983 budget.

Let me turn now to a consideration of what I see as an important part of today's science and technology issues. As I said, in thinking about R&D we have to consider more than simply what kinds of science and technology today's economy lets us afford. More important, we have to consider the reverse -- how can science and technology help the economy?

I think we can make the case that this weak economy we inherited has at least two elements. One is what I would call poor or even irresponsible fiscal management -- primarily the idea that we could afford any popular federal program we wanted simply by printing more money. But the economic chaos of inflation and high interest rates that resulted from those policies caused a serious secondary effect: caution, and extreme preoccupation by business with the short-term.

This problem, in combination with some structural problems that I'll talk about, has caused serious declines in the rate of productivity growth in many of our manufacturing industries. Not very many years ago they were the shining example of American inventiveness and technological wizardry. Today we find one after another of them having their competitive advantage threatened by newer, better conceived competitors in other countries, notably Japan.

We've already seen some large technological industries -- like steel and automobiles -- become severely battered by the competition. I don't want to overreact to the situation, because although our balance of payments in manufactured goods is deteriorating, it's still positive. But we already face a serious problem in the loss of American jobs and -- more important than the loss -- our inability to replace them with other jobs. We should remember that a country like ours, which has a successful history of moving up the technological scale and increasing labor productivity, expects to slough off jobs in aging industries because it can use people better in new industries.

Now, the ironic thing is that some of our technological industries are getting the pants beaten off them in spite of the existence, in the United States, of the best basic research establishment in the world. Our better universities remain the world's best, and our graduate schools are imitated but never equalled. More than 300,000 foreign students are attending American universities today, because they know they're the best.

I guess my first reaction is that in spite of what the economists say, there's no guaranteed relationship between the money spent on R&D and national economic growth. In fact, consider Japan, which spends very little on basic research. Now, I'm not saying you can have economic growth without R&D, but that's obviously not a sufficient condition. Japan is a fascinating example, because they have been successful in a way that we haven't. They've put knowledge to work. It's true that very often it's our knowledge that they put to work, but any of us who have worked in basic research know very well that the transfer process doesn't respect national boundaries. I'll add that the best protection against this kind of information drain is not protectionism but is for us to be as aggressive about using knowledge as we are about producing it.

We know by now that Japan does some things very well, but it would be a serious mistake for us to get carried away in our adulation for that particular economic and social system. We look at Japanese manufacturing and wonder how we might achieve their kinds of process efficiencies and worker productivity gains. But the Japanese themselves are increasingly concerned about their own future because they lack the very strengths that we have in abundance -- creativity and flexibility. According to a recent New York Times article (13 June 1982), the traits that brought such success to Japan's carefully planned and integrated industries now threaten their industrial future.

The article points out three budding problems. First, the Japanese system of management, which is seniority-based, is often ill-suited to fast moving, emerging markets. Second, their system of corporate financing thwarts the startup of new, innovative industries. Third, and I quote, "the country's emphasis on community, obedience, and uniformity, all of which have been crucial to its highly efficient assembly lines, has discouraged individual creativity and, with it, far-reaching product inventions."

So Japanese leaders are now seeing ominous signs that their whirlwind success in building new industries that

capitalized on emerging technologies may now face an uphill battle to continue its successes. In many ways Japan has been able to operate with far lower overhead than have we in the United States. Japan spends far, far less of its public resources than we do for defense, for social programs, and for basic research. So, in a sense, they've been riding free, able to allocate more of their resources into industrialization. But at least some of those problems are coming home to roost. Japan's celebrated worker security system is partly possible because the population is young, with more than twice as many people working per retiree as in the U.S. and western Europe. But life expectancy in Japan has jumped from 55 to 76 years since 1949, so in less than 20 years Japan too will be carrying social support costs for non-workers comparable to ours.

Moreover, it seems that Japanese leaders are also worried about their relative inattention over the years to basic research and to encouragement of creativity in general. Just as the United States was able to make phenomenal strides in technology during the war years because of the backlog of basic science that had been accumulated during the 1920's and 1930's, Japan may have been able to make its rapid industrial advances in the 1960's and 1970's by tapping into a mother lode of new production and manufacturing opportunities that have now been substantially used up. Its high-volume, carefully balanced industrial system is fragile and highly susceptible to shifts in technologies and in markets. How well it will continue to flourish without fresh creative input is an interesting question. I'm not at all sure we should be envious of Japanese industrial methodology, and we certainly shouldn't try to slavishly copy it.

What we should be doing is capitalizing on our own substantial advantages and letting the creativity of our American science enterprise light the way for new industrial innovation and development. There's no question that our future, as a nation, is tied to high technology. That's where the jobs will be, that's where the driving force in international trade will be. Even our premier industry -- agriculture -- may be on the verge of a new revolution because of developing high technology.

Unfortunately, over the years we've failed to take full advantage of our own resources. Researchers in universities, federal labs, and industry have tended to pursue their own interests and have developed their own internal communication networks. Sometimes I'm not even sure that the different scientists and engineers speak the same language. In the short run this inefficiency most hurts industry, which is

impeded in capturing new ideas that might have commercial potential. In the long run, of course, we all suffer if our industries can't compete in the international market.

Our concern at this point has to be for the future. We know that, as a great industrial nation, we've made some serious blunders in recent years. Mostly our mistake was in taking our industrial superiority for granted. We assumed our lead was insurmountable and that upstart economies would, at best, carve out small market niches that we either didn't want to bother with because there wasn't much profit in them (such as, say, small cars) or that they would take over some undesirable, labor-intensive manufacturing that Americans had outgrown. I do think that we're finally beginning to recognize the seriousness of our situation and that we're in an excellent position to do something about it.

Admittedly it would be easier to mobilize the nation's resources into new technological express in the face of something comparable to Sputnik or armed hostilities. Still, I think by now most people would agree that the threat of industrial decline and inability to compete with other countries is a deadly serious threat. I'm suggesting that just as we demonstrated our national capacity to achieve greatness with the space program in the 1960's, we should mobilize ourselves for a comparable surge in industrial strength in the 1980's.

How will we go about making that possible? One way will certainly be to establish closer ties between the people putting science and technology to work and those who are producing the new knowledge. For example, we've introduced measures to encourage industry to have some of its research done in the universities. Now this isn't simply a matter of industries "buying" research from the campus. More to the point is that the process involves a sharing of ideas and of people. At the same time that university researchers are getting a better understanding of industrial goals, industry should be able to offer university faculty a chance to participate in new kinds of research, taking advantage of the kinds of environments they're unlikely to find on the campus.

I'm not suggesting that industrial funds are ever going to take the place of federal funds for university basic research. As I've already said, the federal government recognizes its responsibility and self-interest in maintaining that strong capability. But as one who has to answer to the questions of what kinds of returns the taxpayers get on the billions of dollars spent each year on basic research, I'm certainly anxious to help establish

mechanisms that will improve the likelihood that knowledge will be transformed into public benefit.

Happily, we seem to be seeing some reawakened interest on the part of businesses to make the kinds of long-term investments in R&D that can transform industries. Improvement in the economy, which remains the President's highest priority, is likely to stimulate industrial R&D as individual firms position themselves for highly competitive future markets. There's going to be an extremely active and intellectually stimulating interface developing between some universities and some industries. We're already seeing examples of that in biotechnology. Those institutions that identify appropriate opportunities and devise working relationships will find themselves immersed in what promise to be mainstream areas of science and technology activity for the rest of this decade -- and probably for the rest of the century. They'll have better opportunities to attract additional support for campus research, and they'll be able to attract and retain faculty who find industrial laboratories to be stimulating and well-equipped places to do research.

Universities can't order up a boom in high-school students to reverse the reality of declining college enrollments, nor can they stop youngsters from wanting to be engineers or stop engineers from wanting to work for industry rather than for universities. But contained within new institutional arrangements are likely to be creative approaches to the nagging problems of providing innovative employment and research opportunities for young faculty, to problems of inadequate on-campus instrumentation, and even to shortages of faculty in those fields with high industrial interest.

I think we would all pretty much agree that the United States is undergoing substantial change these days. Although political policies may shift the timetable a little in one direction or another, it was inevitable that we would sooner or later have to face up to the rise of highly competitive industrialism among other ambitious nations. While these are definitely not challenges to be taken lightly, there's every reason for us to take them on boldly. And we scientists and engineers must be the boldest of all.

When we were schoolchildren we were taught that the phenomenal growth of the United States as an industrial nation was primarily a product of abundant raw materials and plentiful, cheap labor. Not exactly. Embedded in our society even a hundred years ago were two even more important

driving forces: a free enterprise system that thrived on innovation and invention, and a form of society that encouraged and admired independent thinking and creativity.

The Reagan Administration is committed to maintaining the world's strongest scientific and technological base. At the same time, a new spirit of innovation must rise from within the scientific and technological communities to merit that support and trust. Merely to fall back on the patterns of reaction to our last great technological challenge, Sputnik, is not an adequate approach to meet today's challenges. We in the scientific and technological communities must respond with new vigor and new vision. I have no doubt we can do so -- but we must first recognize the unique elements of today's challenge and devise new, creative mechanisms to address them. It won't be easy, but the lessons of the past year convince me we can do it.

Michael L. Telson

It is a pleasure to be with you to discuss the prospects for R&D in the FY 1983 budget. In my remarks today I plan to raise the following issues. I'll enumerate them first, then expand on each one in turn.*

First, I will discuss why I feel the prospects for federal R&D spending in the next few years are highly chancy, even though the administration has, under the circumstances, proposed a budget that is generally supportive of basic research.

Second, I would like to review the kind of budget resolution Congress has just enacted, and how it differs from the President's budget.

Third, I'd like to explore the implications of that resolution for the appropriations process, and what you should be aware of as Congress enters that process this year.

And last, I would like to touch briefly on the reconciliation process that the budget resolution has ordered and give you some insight as to what that involves.

Why do I feel that prospects for R&D spending are chancy? Many of you no doubt feel that the President has proposed a reasonable budget in many areas, and I would assume that most of you are relieved that, relative to other areas of government involvement, science has fared well. There are several notable exceptions -- the area of science education, where I think the administration has a problem of ideology, the area of energy R&D, and the area of social science, which seems to have been partly redressed after Congress turned down an ideologically-motivated 75 percent proposed cut last year. One might also quarrel with

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* Dr. Telson is presently serving as the energy analyst for the House Budget Committee. The views expressed here represent only those of the author, and not necessarily those of Committee, or any of its Members.

the emphasis given to defense R&D over that given to civilian R&D, and with the fact that overall decreases have been proposed for applied research, as well as for development activities. However, I think it is fair to say that the administration has been relatively sympathetic to science.

So why am I concerned? The answer is simple. The administration's budget policies are so revolutionary that they are putting unprecedented pressures on certain kinds of federal spending. Controllable spending -- of which science is almost an archetypical example -- is under severe constraints. The administration likes to say that its budget has not really been cut -- that the budget contains growth of $32 billion from FY 1982 to FY 1983. So, it asks, what's all the fuss about? What the administration is not saying is that of the $32 billion increase, $33 billion is for defense spending. It also happens that another $14 billion is in payments for individuals. In addition, another $13 billion of the increase is for interest on the national debt.

This means that all other discretionary programs are going down in one year by $29 billion -- from $103 billion to $74 billion. This represents a drop of 28 percent in nominal dollars and a drop of 33 percent in real terms. To make the story worse, by 1985 the administration expects these programs to be funded at a $66 billion level. This would mean that these programs would have experienced a 61 percent real drop in their level between fiscal 1980 and 1985.

This is an unprecedented reduction. In real dollars, this is the level at which these programs were funded in 1961. At that time these programs represented 22 percent of the total federal budget. Throughout the period since then, through fiscal 1980 approximately, they have represented over 20 percent of the budget -- something under 24 percent. The Reagan budget -- and all of this can be found in black and white on page 9-61 of the Reagan 1983 budget -- proposes to take these programs down to 7 percent of total federal expenditures by 1985.

Whether or not one agrees with the plan -- and I do not -- it is an ambitious one and it is a clear blueprint for radical change. And it has several implications for the scientific community.

R&D spending, as I mentioned, is part of the so-called controllable spending -- spending which is appropriated on a year-to-year basis. It is the category that's being severely reduced, and it is also the category with which most

appropriations subcommittees are concerned. That, of course, is why you should be concerned.

R&D spending is in increasing competition for a smaller and smaller pie. Under the President's budget, R&D will represent a larger and larger percentage of that ever-shrinking pie. As appropriations bills move through their respective subcommittees, and as those subcommittees try to stay within the President's overall budget, R&D programs will be some of the few around from which funds can be borrowed to reduce the hurt in other areas. Let me be very clear. In many program areas, the hurt is very real, it is deep, and it is also politically serious. This means that the hurt will be salved, and sometimes at the expense of R&D. So I don't think the scientific community should be surprised if it starts having troubles in appropriations subcommittees that it never experienced before.

Don't take it personally. It will take more than a President's request to guarantee that Congress actually delivers the money for these programs. It will require, in fact, doggedness on the part of the President and the administration. They will have to be willing to be very flexible politically and to accommodate certain exchanges that will go against their principles. If they are not flexible, I would predict that you will not see much of this money provided through the appropriations process. This will be a key test of the administration's real commitment to these programs.

Maintaining R&D funding will also require a doggedness on your part to cultivate the Congress and to make it understand why your programs are better than someone else's, and why the public interest in these programs and their private interest in you as constituents justify funding your priorities rather than those of others.

Let me give you a few examples of the degree of hurt that has been inflicted on the appropriations process by the President's budget. As you know, the HUD-Independent Agencies appropriations bill is the one where NSF, EPA, and NASA programs are funded. In FY 1982 the level presently anticipated is $61.6 billion in budget authority. In FY 1983 the request is for $41.3 billion. The largest part of this cut is in subsidized housing programs; however, other programs in this appropriations bill are severely cut as well.

The Interior appropriations bill, under which DOE's fossil and conservation activities are funded, provided

program funding of nearly $8 billion in FY 1982, while the President's request for FY 1983 is $6.85 billion.

In the Labor-HHS bill, where NIH and other health research is funded, we have an $88.3 billion level in FY 1982. In FY 1983 the request is $80.5 billion.

So much for the President's budget. What about the first budget resolution for FY 1983 that Congress just passed? How does it change spending priorities from those reflected in the President's budget, and what are its implications for federal R&D expenditures?

Let me give you a bit of background. As you may know, the Republican Senate Budget Committee unanimously rejected the President's budget as a markup vehicle. Why? It's always dangerous to speculate on motivations, but they certainly include a general concern that the President's budget produced too great a deficit, especially in future budget years when the deficit became ever-expanding, as well as a concern that the budget requested defense spending increases so high (an $80 billion budget authority increase from approximately $182 billion in fiscal year 1981 to $263 billion in fiscal year 1983) that they practically forced the drastic cuts in all other discretionary federal spending programs I discussed a little while ago.

The budget resolution ultimately approved by Congress -- and you should remember it was passed by Republican-led coalitions in the House and Senate -- changes that spending mix, but not in a radical way. Basically, the budget resolution saves budget resources by:

- increasing taxes slightly from present law levels (it really just reduces the amount by which taxes are to be cut in the future, as provided by last year's Tax Act).
- cutting defense somewhat, and
- capping federal cost of living pay increases,

and the resolution then uses these additional resources to:

- finance additional non-defense discretionary spending programs, including R&D programs,

- reduce entitlements by less than what the President had proposed, and uses the balance to

- reduce the budget deficit from what the President had proposed.

I will digress to mention that the House Democrats proposed a budget resolution that was more generous for R&D than the House Republican version that passed, as well as more generous that the one the Senate had passed. In fact, it provided $350 million more than what was ultimately approved by the conferees for function 250 (general science and space).

Be that as it may, the first budget resolution ultimately approved by Congress is more favorable to civilian R&D than the President's budget. And if the budget resolution's priorities are followed, the Appropriations subcommittees will have more money than the President proposed to spend on non-defense discretionary programs such as your own.

The first question is whether the President will now support the level of spending approved by the budget resolution, or will he veto any bills that exceed his request, regardless of the budget resolution?

If he says he will veto any bills that exceed his request, that means you're in the same trouble I described to you before. If he supports spending priorities assumed by the resolution, a resolution he supported, it means less trouble.

The second question for you to pay attention to is how the Appropriations Committee of each house will allocate the money that they receive from the budget resolution among all their subcommittees. Once that is done, the subcommittees will be expected to pass bills that are within those allocations. And if they do anything resembling what the budget resolution calls for, the subcommittees that deal with R&D will have significantly increased flexibility over that provided by the President's request.

The third question is whether or not the subcommittees will feel that it is advisable to fund more than the President's overall request while still staying within their budget resolution allocations. If they decide to stay within the President's request, we're back to square one. If they decide to go above the President's levels, while still

staying within the budget resolution assumptions, that will make for a different situation. And I would submit to you that the administration's position on this issue at this time, will have a significant effect on what the subcommittees decide to do.

Despite all this, it is almost certain that Congress will not be able to settle all of its bills before the October recess. In most years, the budget resolution would have been completed by May 15 and appropriations would have moved to the floor almost immediately. This year we're still not finished. As you know, in the House we finished June 23 and Congress is recessing in October. This doesn't leave much time. If Congress is not able to complete these bills, you will be part of the Continuing Appropriations Resolution Game, and that is an art unto itself. I highly recommend it to those of you who have a macabre bent of mind.

Finally, I'd just like to mention what else is going on in the budget process that you might find useful to know, even though it might not be as directly related to your interests as the appropriations process. The budget resolution contains a reconciliation instruction mandating Congress to increase revenues over those in current law, and to cut entitlement spending as well. This reconciliation bill has to be reported by July 20th in the Senate and August 1st in the House by the various committees of each chamber. This bill will deal with the various tax proposals that have been raised including the President's revenue proposals. They will also have to deal with cuts in Medicaid, Medicare, federal pay caps, and some agricultural programs.

So, you see, there are quite a few legislative balls for you to keep your eyes on before final decisions on FY 1983 spending on R&D activities are resolved.

Frederick N. Khedouri

I appreciate very much the opportunity to participate in this Seventh Annual AAAS Colloquium on Research and Development Policy. I hope to learn from your comments and questions; I also hope to dispel some of the mythology that has grown up around the development of the administration's programs in this vital area. Indeed, after reading some of the lurid descriptions of how the administration's R&D budgets would purportedly demolish Western civilization, some of you may have been surprised to see that Jay Keyworth and I have mastered walking upright and that our knuckles did not drag on the ground when we came into the room.

I would commend the AAAS chapter on "Challenges of the FY 1983 Budget" to all of you as a succinct statement of where we stand. It was reassuring to note that its authors managed to penetrate the murk of rhetoric that surrounds the budget and discern what the administration was actually trying to accomplish. A quotation sums it up: "The President's FY 1983 budget, as we shall see, treated R&D fairly well for the most part, given the difficult circumstances." This was by no means an accident, as Jay Keyworth has told you. We made a clear commitment early in the development of administration budget policy that we have maintained steadfastly. We believe the federal government has a large and important role in the support of basic research. But we do not believe that any valid public purpose is served by the establishment of rigid targets or goals based on constant dollar levels focused exclusively on direct federal programs.

The administration has accomplished three very fundamental changes in direction that will ultimately lead to a great strengthening of the total research effort in this country. We have preserved a healthy set of federal programs. But that is a relatively insignificant part of what we have done. Two other factors are of greater significance.

First, we have adopted a very aggressive anti-inflation policy. Notwithstanding the temporary upsurge in last month's consumer price index, it is clear that the basic rate of inflation is now less than half what it was when the President took office. This anti-inflation policy has tremendous

importance in strengthening the total research endeavor because it strikes at the heart of the serious problems faced by our nation's universities and foundations. These institutions have seen their endowments eroded, their purchasing power diminished as double-digit inflation persisted. The implications of this for the maintenance of facilities, the allocation of funds to facilities, support of graduate students, and the many other contributions to research by universities were severe. Those of you who are members of the academic community can readily attest to the inexorable weakening of many of our top private and public universities that resulted from a decade of inflation.

More insidious, a decade of steadily rising federal claims on the national economy, financed by ever higher tax rates, reduced the ability of our private institutions to draw upon the public for support. Individuals, alumni, corporations and foundations could not keep pace with growing needs. This increased dependency on federal support, both provided directly through R&D grants and indirectly through the various programs to support students.

The administration's success in controlling inflation will in effect start to put money back into the pockets of our private research community by ending the erosion of endowments and ending the operating cost spiral.

A second major element of administration support of R&D comes through our tax program. By putting money back into the hands of the taxpayers and creating the conditions for a resurgence of economic growth, we will necessarily make more funds available for research and development. These funds won't ever have passed through the hands of a bureaucrat, so we can't take credit for them in the budget as "federal support of research and development."

For example, the Economic Recovery Tax Act of 1981 contained several elements which are designed to increase private sector activity in scientific research and development, including university research:

- By 1986 when the plan is fully implemented, corporate taxes will be reduced by 50 percent, freeing these funds for further investment, including increased R&D expenditures.

- As an incentive for industrial R&D, the Act provides a 25 percent tax

credit for increases in non-capital expenditures for R&D. As an aid to university-industry cooperative research, this tax credit applies to 65 percent of industrial research grants to universities.

- Also significant to industry and universities alike are the greatly accelerated R&D equipment depreciation provisions of the Tax Act, lowering the depreciation period from 12 or 13 years to 3 years. In addition, university research will benefit from increased industrial tax deductions for donations of scientific equipment.

The direct value of these tax reductions amounts to several billion dollars in incentives and support for R&D across the spectrum of university-industry activity, certainly including aerospace and related work.

We believe these tax reduction proposals are coming just in time. A recent survey by McGraw-Hill indicates that total R&D spending by U.S. companies increased by 16 percent in 1981 and is expected to increase by another 17 percent in 1982. Within this overall increase estimated by McGraw-Hill, we estimate that company funded R&D will increase in 1982 by 10-11 percent. I am not claiming that these increases are a direct result of our tax incentives; however, our policies are intended to encourage such investments by the private sector and we believe would help in sustaining this trend of increased investments in R&D.

In order to understand the administration's approach to R&D support, it is thus necessary to look beyond the budget to the whole range of our economic program. For ultimately it is a strong economy and sustained growth that generate the resources to support basic research endeavors. We can mouth all the rhetoric we want about the importance of R&D to future generations, or the rhetoric that some of our liberal Democratic opponents in the Congress have used about the necessity for massive federal R&D efforts to keep the U.S. competitive in the world economy. But history — going back to the most ancient of civilizations — tells us that societies that generate new wealth through economic growth are far more likely to support the sometimes intangible benefits of researchers. A society that is struggling to redistribute

wealth because it has stopped growing will inevitably start to consume its seed-corn and sacrifice the long-range good generated by the efforts of those who seek to advance knowledge.

Having perhaps waxed a bit too philosophical, I would like to return briefly to the mundane world of federal program budgets. The AAAS report on the challenges of the FY 1983 budget does contain one very serious misstatement of administration policy. In a section describing energy research, the authors state that "administration policy is based on the premises that the country is not faced with a serious energy crisis and that technological developments required to help assure the supply of energy will be financed and carried out by the private sector."

First, we do not dispute that the nation has a serious energy problem that will require the development and application of many new technologies. What we dispute violently is the premise of the prior administration that the transition and adjustment set in motion by the sharp increase in oil prices in the early 1980's must be managed and centrally planned by the federal government. The conventional wisdom of the past five to seven years has been that energy is a problem to be solved by the application of something very much akin to a Soviet five-year plan. But what we see in practice, of course, is that much of what passes for "research" in the energy budget is actually just another variety of pork-barrel public works. The devastating impact of these so-called R&D efforts in stifling private and commercial technology development far outweighs any alleged benefits. We have maintained very strong programs, with real-dollar increases, for basic energy sciences. The vastly more costly programs aimed at constructing a series of energy white elephants across the land were targeted for elimination. It demeans the rest of the research community to dignify the energy programs we eliminated as "research and development."

I am not one to make long-winded speeches, fortunately, and Jay Keyworth has already pointed out to you most of the salient details of our federal FY 1983 R&D budgets and the policies that guided their development. As I indicated at the outset, I am here more for my benefit than for yours, to try to hear from the group what we are doing wrong and what we are doing right.

Frank Press

I want to start with a bit of praise for this annual event. In fact, I think other organizations should conduct this type of symposium and analysis for the defense budget, for the health budget, for a few other major items in the budget and the country would be ahead indeed. The analysis of the R&D budget that goes along with this meeting has become essentially the "bible" for those who want to understand the science policy of a particular administration.

Something extraordinary happened at the recent summit at Versailles: science and technology entered the consciousness of the heads of state. Science and technology are now recognized as major factors in the future economic development of the large industrial democracies. The subject has already been placed on the agenda for the next meeting of the heads of state in Washington next year. The large industrial democracies now recognize that their future lies in new industries spawned in a high technology industrial revolution. This is bound to affect attitudes in our own country in the Executive Branch and in Congress.

I would like to make the following points during the course of my remarks: First, we are number one in science and technology today. It is the future that is of concern. Maintaining our scientific preeminence and transfering new scientific knowledge to industrial practice -- these are among the primary issues of our time. Second, in the past few years there has been a major change in the attitudes of U.S. industrial managers. They have begun to recognize the importance of investment in long-term R&D and of allowing for significant real growth in industrial R&D budgets even in times of severe recession. Third, a parallel government effort to provide for real growth in basic research could position the United States in the strongest competitive posture. I will suggest that there are many opportunities for reorganizing and reprogramming federal R&D funds that would allow for real growth and make U.S. science more productive with minimal budgetary impact. This would require an unprecedented process of evaluation, reorganization and reallocation in the face of bureaucratic and political opposition. It has never been accomplished before, but this

is one administration that seems willing to try and might bring it off. It is, however, a very risky and dangerous operation. Finally, I would like to propose a specific policy for the federal support of science appropriate for these times.

Let me take up these points one at a time, but not necessarily in this order.

First, why does research deserve high priority support by government and industry? One hardly needs to make the case for this audience, but let me do it in a novel way. A few years ago I had the occasion to query cabinet officers and agency heads and to ask them to provide a list of unanswered questions in science and technology that could be extremely important to this country if we were able to answer them. They came back with some 50 questions. Of course, many of these cabinet officers were not scientists, so they turned to their own agency heads to help them gather and formulate these questions. Many of the questions will be answered in the next ten to twenty years, given adequate support for science. Here are some of them:

- Can we discover antiviral agents to combat viral disease? This would be a tremendous breakthrough.
- What are the molecular mechanisms by which genes are regulated to produce specialized products, and what new information is required to exploit the new recombinant DNA technology?
- To what extent can laser-induced chemistry be used as a practical synthetic tool? This could open up whole new industrial practices, requiring low energy and with few environmental side effects.
- How do catalysts work?
- Can simple chemical reactions be discovered that will generate visible radiation?
- What is the nature of climate?
- What is the petroleum potential for the deep continental margin beyond the continental shelf?

- Can man-machine interfaces be made simple enough to allow real-time translation by untrained personnel? We're going to see that in the next 20 years. Such developments would not only provide improved communication between nations but also have a profound effect on our daily life.

- Can new materials be developed which would be less dependent on critical or strategic minerals and would be noncorrosive and very strong?

- How can the environmental stress tolerance of current crops and grasslands be improved by genetic manipulation? If we are able to solve that problem, some 40 percent of the world's uncultivated but potentially productive land can be brought into production.

- Can materials be found that exhibit superconductivity at room temperature? This would revolutionize energy transmission and energy policy.

- What are the limits for communications use of the channel capacity in the visible spectrum? This question is of tremendous consequence in the new computer-communications industry.

If we can answer some of these questions and others on the list, we can in the next ten to twenty years transform industry, agriculture, health, defense, energy, and resources. The effects would be enormous. The potential for new jobs and for growth in our gross national product is, as I said, huge. Those questions dealing with electronics alone have the potential for creating more jobs than currently exist in automobiles and steel combined.

This is all by way of a preface to a statement. Namely, that the national support of science and technology deserves the same priority as defense, tax cuts, and deficit reductions.

Let me turn now to another point that I mentioned in my introduction: the turnaround by U.S. industry, the new

attitudes of management concerning research and development. Fred Khedouri alluded to this in his remarks. One can find a very convenient summary in the McGraw-Hill survey that was completed in May of this year.[1] The survey found that firms plan to hike R&D spending during this year of recession by 17 percent. And that's on top of a 16 percent increase in 1981. They project that expenditures will increase by 37 percent hbetween now and 1985. These results suggest that something of an R&D renaissance is underway in the private sector. U.S. industry is once again depending on R&D to further, or perhaps regain, its lead in the technological marketplace.

In the period 1970 to 1975, real spending on R&D was reduced by more than one percent. During the next five years, 1975 to 1980, real growth of 5.8 percent occurred. Contrast the year of recession, 1970, when capital spending was up 6 percent but R&D went down by the one percent that I mentioned with the current year. In 1982, we have a more severe recession, capital spending is down about 3 percent but the R&D budget of industry has been protected and will go up by an unprecedented 17 percent. So the pattern of sacrificing the long-term in favor of the short-term in industry is being broken. And even with reduced capital growth, companies are planning to increase their spending for research and development.

Why is industry making this remarkable change? Perhaps one reason, as Fred Khedouri mentioned, is the Economic Recovery Tax Act of last year which provides tax incentives, tax credits for R&D expenditures. But the increase actually began before this tax program was set in place. I think, as the McGraw-Hill report suggests, that in the face of international competition, the energy crisis, the technological challenge from Japan, and the slow growth of an economy plagued by inflation, U.S. companies may well have decided that R&D was the place to start breathing new life into their businesses.

I would like now to talk about a parallel effort for basic research on the part of the federal government which, together with industrial investment, can make for an extremely powerful combination. I'd like to propose a compact between government, industry, and universities for the support of basic research. I presented this idea in my

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1 "27th Annual McGraw-Hill Survey of Business' Plans for Research and Development Expenditures, 1982-85." Available from Economics Department, McGraw-Hill Publications Department, 1221 Avenue of the Americas, New York, NY 10020.

testimony last December before the House Science and Technology Committee.

This would be a compact establishing new national goals for the support of science. It would work in the following manner: The basic research budget for the federal government should increase each year at a rate that would cover inflation and permit a few percent real growth. This annual rate of increase would respond to the need for stability and predictability in establishing long-term planning goals and also provide for the intrinsic inflation in the costs of doing science as new methods and new techniques emerge. This might be considered the base program for scientific fields. In addition, another small increase annually, real growth, would be provided either to support special targets of opportunity in particular fields or for areas of research related to particular national needs or to provide supplementary funding to assist with essential instrumentation and research facilities. Within present levels of support, the scientific community and the government would cooperate to find means of transferring funds from less productive areas and institutions now supported by federal research funds to more productive areas. Increased productivity could be achieved by reducing indirect costs, reducing regulations that force indirect costs up, and improving the efficiency of research by granting longer-term awards. I believe that we can find a 2 percent annual increase for science, for the working bench scientist, in this manner. A commitment from industry to increase its share of the support of U.S. research universities, by one percent a year -- that amounts to about a $50 million increase each year over the amount that industry has been giving -- would have practical and symbolic significance. Incidentally, I believe this may already be happening.

To insure continuation of adequate support of graduate education, a partnership including government, industries and universities is proposed. The partnership would work in the following manner: NSF and the mission agencies would support a coordinated program of national research fellowships and traineeships. NSF would provide basic support for an overall program of merit -- that is, the best people regardless of fields, much along the lines of NSF's current activity. The mission agencies would provide fellowships appropriate to their own function. Examples might indicate EPA fellowships in toxicology, where there is a severe national shortage; DOE fellowships in combustion sciences and engineering; and DOD fellowships in computer sciences and integrated circuits. Defense has already taken the lead and has initiated such a program.

In addition industrial firms should be encouraged to establish additional fellowships, named after their own companies perhaps, in fields where their needs are greatest. And if all of these funds could be pooled in a central depository with some central agency or institution making the selections, we could have, at relatively low cost to any particular sector, a magnificent national program in support of graduate education. And such a compact between government, industry and universities could provide the commitment for assuring the stability, predictability and real growth needed for a strong U.S. effort in science and technology.

How can we finance the federal portion of this program at a time of budgetary constraint? Let me remind you that the basic research budget of the government is $5.4 billion a year. The applied research budget is $7.2 billion and the development budget is $26 billion a year, of which some $19 billion is in the defense area. Now these categories all flow into one another, so let's assume that in terms of basic science and basic engineering we are talking about some $7 billion a year. That's the kind of budget that is of concern to most of the people in this room.

In that huge $26 billion development budget, I know that it is possible to find $700 million a year that isn't productively spent, that could be transferred to basic and applied research and by itself would provide the real growth of 3 or 4 percent above inflation that I've been talking about in this proposal. I think we have to really consider the possibility of identifying unproductive institutions wherever they are -- whether they're national laboratories or universities -- and transferring their funds into more productive areas. You could find a few hundred million dollars a year that way.

Now this will require a substantial degree of evaluation of national laboratories, universities, and government-sponsored research in industry in areas such as energy, health, defense, agriculture, environment, and so on, especially in development projects. This kind of evaluation, reorganization and reallocation is really unprecedented. It will require cross-agency transfers within the Executive Branch and agency heads, cabinet secretaries and their respective Congressional committees will fight that.

There are many bureaucratic and political problems in this. It's really quite risky. If one undertakes this and identifies weak, unproductive areas, the result may be not a budget transfer but a budget cut, and that is why it is

risky. But it is nevertheless true, as George Keyworth has been saying, that in this enormous R&D budget of some $40 billion a year, it is proper for the government to ask "What is appropriate for the government to do in basic research, and what is appropriate for industry to do in development and demonstration? Cannot some of the huge funds that the government spends in development be better spent in basic research?" If Keyworth can bring this off, more power to him because the resources there are tremendous. He deserves our support in these efforts. If he can't bring this off because of bureaucratic opposition, then it will take some $700 million a year, beginning in next year's budget, to provide the kind of real growth in basic research that I think is important to this country's future.

Is that a lot of money? The Clinch River Breeder Reactor can support three or four years of real growth in basic research just for the cost of that one demonstration project. Real growth for a full year in basic science is equivalent to two B-1 bombers. I think we have to keep that perspective in mind.

Sitting up here and listening to Jay Keyworth I couldn't help but remember my own role when I had his job. There are a lot of things that one does in that job that one cannot take credit for. I'm talking about the inside government activity where you try to expound your philosophy around that table in the Roosevelt Room of the White House, where you try to make a case for why science is important to this nation's future. And I remember last year that Keyworth counselled the scientific community during that budgetary crisis when we all thought that we were going to have an across-the-board 12 percent budget cut. He said, "It's not going to be as bad as you people fear." And, that's the way it turned out. In many areas of basic research, he did achieve real growth, and I know he had to fight for it. As was pointed out earlier this morning, within the largest deficit in federal history, science was relatively well treated. Keyworth seems to have the courage to tackle these very difficult and politically dangerous issues of evaluation, reorganization, and re-allocation in order to put money into the best scientific institutions, the best people in the country. I think we should give him credit for this. None of his predecessors were able to accomplish this, but in principle, in concert with the industrial development that I described to you, it can lead to the strongest U.S. program imaginable.

I feel, however, that the compact to provide stability and real growth for basic science in this country that I have just described is so important that if new funds are required

in the amount of $700 million because of difficulties in reorganization, they should receive the highest priority consideration by the Executive Branch and the Congress.

So, let me summarize: I believe that priority support of U.S. science and technology in government and industry is eminently justifiable. It will make a significant contribution to a strong U.S. economy, to industry, agriculture, health, the important need to improve our non-nuclear defense capability so that we can reduce our dependence on nuclear weapons, and to a lot of other areas as well. I think U.S. industrial management has recognized this and U.S. firms are putting their money where it counts, in long-term research and development, as a fact of their future life. I believe that the government should undertake a parallel effort in the much smaller area of the basic sciences. The federal R&D budget is so huge, I remind you, that a one percent reduction in development is equivalent to a five to ten percent increase in basic research, depending on how you calculate it. It should be easy to find and weed out unproductive and inappropriate development and demonstration and use those funds to support a major part of the growth in research. And, as I said, if all of the preceeding cannot be accomplished for political or bureaucratic reasons, then new funds are eminently justified in view of the enormous returns.

LUNCHEON

Presiding:
William G. Wells, Jr. *(Head, Office of Public Sector Programs, AAAS)*

Address:
Margaret M. Heckler *(Member, U.S. House of Representatives)*

Luncheon Address

Margaret M. Heckler

It is both a pleasure and an honor for me to join you today. Those of us in Washington who work on science- and technology-related issues are all familiar with the Annual AAAS Colloquium on R&D Policy.

There is some hesitation however. One thing I have learned in my 16 years in Congress is that some years are better than others. I suspect that this is not one of our better years. I know I am safe here though, because in the preface of the AAAS R&D Report, it states, and I quote, "It should be emphasized that neither this report nor the AAAS Colloquium is undertaken in advocacy of R&D programs or budgets, or of any particular view on controversial issues." I somehow doubt that all of you have come here today in order to avoid controversy or with a neutral attitude about the R&D budget.

In my opinion, that is exactly the way it should be. Most of you have been a part of this country's scientific enterprise for many years. You have worked together to develop a nationwide research and development endeavor respected around the world. All that work, you think, and then Washington comes along and changes the whole business.

The process sounds like a story I heard of a man walking into a crowded restaurant and hanging his umbrella on the coat rack. To insure its safety he attached the following note: "I am the world's greatest wrestler, and I am returning." Well, after finishing his meal the gentleman returned to the coat rack, and finding no umbrella, read the following message attached to the rack: "I am the world's greatest runner -- and I will not return."

I know some of you feel that Washington has run off with your budget. We are not, however, the world's greatest runner. And to the extent Washington has run off with your budget, I am sure it will be returned to you soon. A little worse for wear perhaps, but still able to withstand the elements.

Looking at the FY 1983 R&D budget I would say that some sectors of the research community have already made their mark. Research spending is up 11 percent over FY 1982, though the non-defense portion has remained stable, before inflation.

While I continue to have some concern over the R&D budget, especially with the shift into defense areas, I have a much stronger feeling about how we are maintaining our human capital. America is in trouble. Not simply because of a declining investment in basic research, but more because of the broader strains a society hurtling into the 21st Century will place on its educational system. Unless some fairly drastic changes are made in education policy, and the way all levels of government support that policy, America may be brought to its knees by the process of modernization itself. We are fast approaching what I call the "human capital fix" -- a point beyond which a society simply cannot efficiently use new innovations to meet human needs, increase production, assist our national security, and fuel new increases in our standard of living.

Before I go on to discuss the human capital idea in a little more detail, I do want to make one observation on how the Congress views R&D. Most observers would agree that last year's budget authorization was certainly unique. The President's use of the reconciliation process enabled all his budget recommendations to prevail -- almost. There was one exception. Little did I realize when I stood up on the House floor to defend the Science and Technology Committee's budget for the National Science Foundation, which was $70 million over the administration's recommendations, that 60 Republicans would join me in approving the only budget authorization to exceed the President's request last year.

Now to me that says something about how the Congress views not just the work of the Foundation, but of science and technology in general. Few members of Congress have an intimate knowledge of science, but we are no less susceptible to the advances made in our daily lives by what research and development provide.

As policymakers, we need more than a laundry list of complaints and desires. Every constituency has its wish list. We need to understand what you are doing, and why it is important. The dialogue between the scientific community and other members of society is sorely lacking. There is one thing the "budget battle" has brought us, however, and that is closer together. I hope these initial linkages will grow and strengthen.

Now let me get back to the "human capital fix" problem. I mentioned earlier that we will reach the "human capital fix" at that point when our society can no longer make efficient use of the scientific and technological innovations made available to it.

This may not be a new concept. There certainly are particular fields or industries that experience personnel shortages of one type or another. I can think of a few examples. The high technology industry is experiencing shortages of skilled and semi-skilled workers. So far these shortages have not been too dramatic, though serious. We have also seen what happens when scientific advances with potential commercial applications, like biotechnology, catch an unprepared and under-staffed industry by surprise. The private sector quickly rushed to the universities to make research pacts where industry will not only obtain research results, but also a more valuable actual transfer of the technology itself. In short, we know shortages can and do occur, but the system appears to adapt and survive.

I would like to make two observations that I think jeopardize the survival of our continued prosperity. If I might borrow a line from Daniel J. Boorstin (Librarian of Congress) in his book The Republic of Technology: "What is most significant about technology today is not so much any particular change, but rather the dramatic and newly explosive phenomenon of change itself."

This is my first observation, and it is, to all of you, probably obvious. Change is now occurring so rapidly in scientific and technological fields that we have no experience by which to judge the results of that rate of change. We have an idea of what can happen in the private sector, and I know most of you have experienced what is happening in higher education: institutions are pushed to their limits as they expand to embrace new disciplines and tangents of research and scholastic inquiry.

But more importantly, what will the strains be as the exponential explosion of change rips through American society? Can our institutions effectively respond to the requirements of increasing complexity in the workplace when, for example, one in five American adults is functionally illiterate -- unable to read, write or understand basic concepts?

Will America be able to compete with our industrialized partners when their science and math education requirements and per capita graduates far exceed our own?

My second observation, and the two have to be considered together, is that the inexorable demographic changes underway in this country exacerbate the problem and point to some very serious consequences if we don't respond.

The offspring of the post-World War II baby boom have reached maturity, resulting in a dramatic reduction in the work force growth rate. The expected consequences are that in 1990 over 90 percent of the workers will come from the ranks of those working today. By 2000, the figure drops to 75 percent. This means that the growing employment needs of an increasingly complex work environment will be met, not by a new cadre of science and math qualified graduates -- which we already know is inadequately prepared -- but rather from the ranks of those currently in the work force.

This might not seem so threatening if it were not for the hundreds of thousands of workers who will be displaced every year as a result of automation, domestic and international competition, robotization, and the continuing shift to a service-based economy. Peter Drucker estimates 20-30 million workers will be displaced by these factors in the next decade.

Do we have public or private institutions capable of meeting this demand?

Let me complicate the situation a bit more. Over 65 percent of the new entrants into the work force in the next decade will be women, up from 37 percent in 1960 and 50 percent in 1981. In addition, 1978 marked the first year the number of women enrolling in college exceeded the number of men. The emerging work force will also be composed of a growing percentage of minorities.

Are our public and private institutions prepared to make maximum benefit of these new female and minority workers?

Here, in effect, is what my observations seem to indicate. First, exponential change is resulting in complex demands on the workplace in terms of millions of displaced workers in need of training, retraining and upgrading.

Secondly, American demography dictates a smaller emerging work force, over 75 percent of which is women and minorities. The graduates of this decade, no matter how well qualified, may be important for research and development advances, but they will comprise a mere 10 percent of the available workers through 1990 and only 25 percent of the available workers by the year 2000.

The combination of these two observations, namely the growing displacement of workers as the structure of our economy changes and as the skill requirements increase in the workplace, and the fact that these very same displaced workers will comprise all but 10 percent of the total labor pool, would seem to indicate that the sheer size of the re-education necessary will exceed our current capabilities.

Industry is already spending about $30 billion for upgrading and retraining. I would question its ability to take on much more. I don't think the universities and colleges are ready either, although with a declining student population you would think re-education offers an exciting potential.

In April, in an address to a special convocation at the National Academy of Sciences, I said that the United States stands poised at the brink of an education manpower training crisis that will make our emergence as a world scientific and technological power akin to the maiden voyage of the Titanic. We believe that our ship of state is invincible and its progress inevitable up to the point at which a scientifically-illiterate work force drowns one area of scientific and technological expertise after another.

I have not seen any information that would change my opinion. This sounds like a great grant proposal for some enterprising research department!

In summary, I think the R&D budget needs continued watchful diligence and support. More important perhaps, is a set of broader questions surrounding the nature of our changing economy and the effects on the workplace and the schools. I see some great opportunities here. New linkages can be forged between higher education and industry as universities move into the re-education field to augment a decline in the traditional student population while at the same time meeting a national need. There is a clear need here for the practitioners of the social sciences, especially for those familiar with the needs of women and minorities.

Let me conclude by admitting that there is also a role for the Congress. Legislation to assist industry in retraining, using tax credits for example, will be important. I will also be submitting very soon a bill that seeks to upgrade secondary science and math teachers through in-service training programs, and aids post-secondary research and development by providing up to $100,000 to hundreds of researchers throughout the country. There are other legislative needs and, frankly, it will be up to you to make those needs known.

America is a nation made great by its scientists. I sincerely believe we are going to need the best you have to offer in the coming decades. For the sake of our continued prosperity I hope your intellectual largess will overcome and exceed Washington's budgetary stinginess.

Let me borrow again from Daniel Boorstin's Republic of Technology in closing. He relates the opening of the 1876 Philadelphia International Exhibition, with the gigantic 700-ton Corliss steam engine as its centerpiece towering over 8,000 machines spread over 13 acres.

"Not all of the visitors were impressed, though. 'I cannot say that I am in the slightest degree impressed,' announced the English biologist Thomas Henry Huxley, 'by your bigness or your material resources, as such. Size is not grandeur, and territory does not make a nation. The great issue, about which hangs a true sublimity, and the terror of overhanging fate, is what are you going to do with all these things?'"

Over 100 years later, we have many more "things" to do something with. The Congress will rely heavily on you for the right direction.

THE CHANGING CLIMATE FOR INDUSTRIAL R&D

Moderator:
Robert L. Stern *(Senior Associate, Institute of Public Administration)*

Speakers:
Arden Bement *(Vice President for Technical Resources, TRW, Inc.)*

D.V. D'Arbeloff *(Chairman, Board of Directors, and Chief Executive Officer, Millipore Corporation)*

George R. White *(Vice President for Research, Development and Engineering, Xerox Corporation)*

Daniel Adams *(Chairman, Advanced Genetic Sciences)*

The Changing Climate for Industrial R&D

Introduction

Robert L. Stern

This panel will provide views on the country's deployment of R&D resources, as seen by managers of technical enterprises in industry. Our four speakers come from different parts of the industrial R&D landscape; each will necessarily reflect sensitivities developed by his own environment. However, the composite will help us understand the response to current conditions by the high-technology private sector. We were reminded this morning by Dr. Keyworth that this sector is the most crucial in terms of protecting our national interest in the long run.

One other comment before we begin this panel's deliberations. In the analysis of the nation's R&D budget, provided by AAAS as well as by most other practitioners of this art, federal R&D expenditures are arithmetically added to industry R&D expenditures and the R&D funds available from universities and foundations in order to arrive at the national total. While carrying out that mathematical operation is easy enough, interpretation of trends in the resultant total is not. Industry R&D funding arises from motivations very different from the federal and other ones; hence, simple addition of the R&D funds expended towards very different goals leads to totals that have little real meaning. Extracting public or private policy implications from the growth or decline or internal substitution in this total, becomes a risky process. Our speakers will point to some of the distinctions they see and give us some eloquent examples.

Arden Bement

I am delighted to have the opportunity to share my views on the impacts of federal R&D policies on industry. I will address this subject from the perspective of a technical officer of a large, diversified, multinational company. TRW Inc. ranks 71st among the Fortune 500 companies based on 1981 sales, which totaled $5.28 billion. The company provides high-technology products and services to transportation, electronics, aerospace, industrial and energy markets. Our company-funded R&D focuses primarily on using new technology to develop new products, manufacturing processes and services; to achieve higher quality and productivity; and to improve our internal management and operating systems. Accordingly, we seek to establish proprietary positions and to maintain a lead in certain key technologies, such as: micro- and opto-electronics, computer-aided systems and software, fluid mechanics, improved materials, advanced manufacturing technologies, nondestructive testing methods, information systems, and a number of other critical technologies needed to help us accomplish our business goals.

What are the Impacts and Fundamental Questions?

In reviewing last year's colloquium proceedings, AAAS Reports VI and VII and other recent writings on federal R&D policies, several persistent trends stand out -- especially as they may influence future policies. Those which seem particularly salient are the following:

- The diffusion of technology throughout the world is accelerating with the increasing efficiency in information processing and transmission.
- The role of technology as a strategic competitive force for world markets is increasing.
- The percentage of world science and technology generated in the United States is decreasing as overall investments in science and technology abroad continue to increase.

- Collaborative relationships among federal agencies, industry, and universities are increasing as the United States attempts to stand its ground in world trade through reindustrialization and the establishment of more competitive trade strategies.

- The percentage of R&D in the United States funded by industry has in recent years become greater than 50 percent of the total funded by all sources, and the growth of industry's segment is expected to continue.

These trends indicate to me that our federal policies in R&D should be oriented not only to sustain our world preeminence in the creation of new science and technology but also to promote the application of existing science and technology to meet our societal needs. In particular, we must focus our attention on reducing the lead time required by industry to commercialize technological innovations. An increasing vigor in the transfer and application of technology is essential for rebuilding our competitive momentum in world markets.

The approach taken by the Reagan Administration to stimulate private sector investment in capital improvements and new technology has combined several measures, including a reduction in the growth in federal spending, tax incentives for R&D investment, accelerated cost recovery system (ACRS) and regulatory reforms to redirect investment resources from defensive R&D to productivity improvements and business growth. As AAAS Report VI has pointed out:

> "He [President Reagan] has accepted and is beginning to implement the doctrine -- widely held in industry -- that 'degovernmentalization' of the private sector will unleash industry to cure its own ills and get the economy on the track to recovery. Now it will be up to industry to deliver. [emphasis added]"

Within this context the magnitude of year-to-year outlays of federal R&D funds, some of which are interchangeable among federal agencies, should not divert our attention from seeking answers to several fundamental questions, namely:

- What can or should industry do in the face of these trends, issues, and administration policies?

- How do we depoliticize the process of achieving balance and continuity in federally-supported, long-range basic research?

- Are the roles and missions of our federally-funded R&D centers consistent with our current and future needs and priorities?

- What are the best methods for allocating federal resources among R&D performers to encourage excellence, achieve leverage, and facilitate technology transfer?

- How much federal spending is enough in the context of total national R&D spending?

- What are the obstacles and inhibitions which must be removed to provide positive answers to these questions?

These issues deserve our best thinking and should form the frame-work for a federal science and technology policy, which remains as elusive as ever.

What Can and Should Industry Do?

There has been little time for industry to respond to relatively recent policy shifts. However, even in the face of a dramatic economic slump extending nearly four quarters, industry's response has already been positive. Industry's recent support of R&D has not only exceeded past NSF projections, but has also more than kept pace with inflation. In AAAS Report VI, industry's expected expenditures for R&D in 1980 were estimated to represent a 13.7 percent increase over 1979. Surveys recently released by McGraw-Hill Publications Co. show that R&D expenditures by industry in 1981 topped those for 1980 by an estimated 16 percent, compared with the NSF projection of 14.9 percent, and expenditures for 1982 are expected to be greater than 1981 levels by 17 percent. According to the McGraw-Hill survey, R&D expenditures by industry are expected to increase from $59.7 billion in 1982 to $81.5 billion in 1985 for an increase of 37 percent.

With the drop in inflation over the past year, these numbers take on an even greater significance. For example, the administration's estimated inflation rate for 1982 of 6.98

percent, which was viewed with considerable skepticism a year ago, now appears to be an overestimate. This drop in the inflation rate has to comfort colleges and universities which have been struggling to replace obsolete equipment and have faced the dramatic erosion of their federal grants in constant dollars over the past decade.

A major question, however, is whether industry is placing a higher percentage of its R&D investment in basic research, and especially, whether it is funding more basic research at colleges and universities. While AAAS Reports VI and VII indicate that this is the case, it is easier for me to cite specific numbers for TRW (which I believe are consistent with general industry trends).

Capital expenditures by TRW have steadily increased from $200 million in 1979 to $263 million for 1981. Over this same period company-funded R&D (Financial Accounting Standards Board Statement 2) has increased from $59 million to $91 million, representing an increase of 54 percent. Of particular note, the increase from 1981 to 1982 is projected to be approximately 35 percent, compared with an average increase of 16.4 percent for all industry from 1979 to 1980, as reported in Table 5-6 of AAAS Report VII. In addition to R&D, per se, TRW expenditures for related new product developments increased from $103 million in 1979 to $143 million in 1981, for an increase of 39 percent. These increases in capital, R&D and new product investments represent relatively long-term programs tied to strategic business plans and not to short-term forces in the economy. Likewise, a growing percentage of our R&D investment is being focused on "must-have" technologies for the future, such as transportation electronics, new energy production and conversion technologies and strategic materials substitutes. This longer-term thinking has led to a growing investment in university R&D through the establishment of special relationship programs. The ground rules for establishing such relationships are straightforward and relatively few:

- Attention is focused on the faculty and students.
- The relationship is sustained with active and frequent peer interaction.
- The relationship is based on a meaningful quid-pro-quo.
- Interest is exhibited at all levels of the company.

- The relationship is expected to be an enduring one and is tailored to the special roles and needs of the university.

TRW's investment in special relationship programs over the 1981-82 academic year has amounted to over $1.3 million. This amount includes some large investments, such as a $750,000 grant to the Stanford Center for Integrated Studies and $450,000 invested in the Purdue Computer Integrated Design, Manufacturing and Automation Center. However, there are also new program starts at the $10,000-$50,000 per year level. An important point: these special relationship programs are funded from company operating funds, and have been substantially motivated by the R&D tax credits permitted under the 1981 Economic Recovery Tax Act.

In several of these special relationship programs TRW has joined other companies to provide financial support and to play an active role in steering the program, advising the university investigators, and exchanging technical information. Also, opportunities are afforded to faculty and students to retain close association with their research developments as they are taken to commercialization in the company's engineering development centers. This process normally takes from 3 to 5 years or longer after the demonstration of technical feasibility on campus. This "real world" coupling, and the shared rewards that come from it, are now being actively sought by university scientists, since they add new dimensions to their research not generally afforded by federally-funded programs. The establishment of consortia, such as the recently announced National Semiconductor Consortium, has also been encouraged by the clarification of antitrust guidelines for R&D by the Justice Department under both the Carter and Reagan Administrations.

One of TRW's management priorities for the 1980s is the sustained development of high quality managers and technical specialists. Considering attrition, we need to absorb and train about 6,300 new managers and 14,000 technical and professional people by 1985. That is an enormous challenge in the face of both a decreasing input in the supply of college-educated men and women and the economic ills besetting educational institutions. TRW, along with other companies, is especially mindful of the crucial problems facing universities and has established an aggressive university relations program to be supportive wherever possible.

A major element of this program is increased giving for higher education through the TRW Foundation and by company

divisions. In 1981 the Foundation increased its giving to education by 33 percent over 1980. In addition to $1.25 million in grants from the Foundation, an additional $165,000 was given by TRW Inc., making a total of $1.41 million in contributions to education in 1981. The Foundation's contribution plan through 1986 calls for nearly doubling grants to education, at which time education will receive 40 percent of the total in Foundation giving. This stepped-up giving is a direct expression of the company's concern for the quality of science and engineering education and its impact on industry. It is also responsive to President Reagan's call to the private sector to do more in offsetting declines in federal spending.

Merely citing these numbers, however, does not describe the full measure of TRW's response to the current plight of universities. The company has identified targeted programs to address several major problem areas, namely:

(1) The serious shortfall in young faculty,

(2) The shortage of domestic students pursuing graduate degrees,

(3) The obsolescence in computers and research equipment, and

(4) The shortfall in R&D funds.

The programs established to respond to these problems include faculty assistantships; augmentation fellowships; a postdoctorate fellowship in manufacturing engineering to provide for study abroad; equipment grants and loans; employee training programs, fellowships, and stipends; and the special relationship R&D programs mentioned earlier. In addition, top TRW executives have been assigned to fifteen key universities of specific interest to TRW to become acquainted with their needs and to marshall company resources to respond to these needs. In many instances it is the direct involvement of company personnel as adjunct faculty, as members of visiting committees and boards, or as collaborating investigators that is most supportive. Furthermore, as an incentive to encourage contributions to educational institutions by company employees, the TRW Foundation now provides a two-for-one matching grant for individual gifts.

Finally, TRW Foundation contributions to education and personnel commitments have recently been extended to support the upgrading of science education at secondary schools in communities near company operations. These initiatives are

consistent with the current administration's philosophy: a more distributed base of support for education, and greater private sector commitment and involvement. They are also responsive to needs to overcome deficiencies in secondary school teaching of math and science, current NSF efforts in this respect, and the appropriate roles of industry in local communities.

What is Needed to Balance Resource Allocations?

While I have focused on TRW's initiatives, the pace of university-industry relationships throughout the United States has quickened over the past few months, motivated in part by changing federal policies. I also believe that industry's support of basic research at colleges and universities over the next three years will continue to exceed past projections, irrespective of the speed of economic recovery, because of the overriding, pervasive, longer-term needs of industry for both technology and talent. However, an example of a politically-inspired obstacle which unduly distorts sound science and technology and the optimal allocation of R&D resources is the current "Small Business Innovation Act". If such distortions to R&D resource allocations are to be avoided, industry must oppose such "set asides" and do a better job of public and legislative communication.

In concluding these remarks I would like to comment on the federal R&D budget for FY 1982 and FY 1983. The projected 11.8 percent increase between FY 1982 and FY 1983 in overall federal expenditures for R&D and the corresponding increase of 9.6 percent in basic research will build dramatically on the momentum established during the Carter Administration and the first year of the Reagan Administration in achieving real growth in federal R&D outlays. This continued real growth has been achieved in the face of a very difficult transitional adjustment in our economy. On the other hand, the federal budget does not provide sufficient capital outlays, nor will industry be able to contribute enough, to solve immediate needs for modernizing university research facilities. In my visits to several leading universities I have found that a number of bright young faculty are abandoning their academic careers in favor of industry, not just because of a higher salary as commonly believed, but also because of valid concerns that they will not be able to stay at the forefront of their scientific field using obsolete equipment and laboratory support systems.

In comparison with the compounded crises at universities, including the shortage of young faculty, the decline in domestic Ph.D. candidates, and aging equipment and physical

plants, most federal laboratories are relatively well capitalized and generously funded. Therefore, I question whether it is appropriate for the federal government to continue allocating a third of its R&D budget to the more than 700 federal research laboratories. The current reexamination of the roles and missions of these laboratories by OSTP must be translated into timely policy actions to relieve current pressure points at colleges and universities.

Looking at the universities, however, I believe that substantial improvements are possible in the productivity and quality of R&D performance and in the needed redirection of academic programs through the adoption of better management techniques, the discipline of strategic planning, and in some cases the enforcement of tighter space and energy use standards, even at the displeasure of senior faculty. This is an area where assistance from industry could be helpful.

A final comment: the administration has reduced R&D funding for the social and behavioral sciences. That is not in industry's long-term interest. Industry has much to learn about economics; human cognition; group and organizational behavior; ergonomics; quality of life; productivity, motivation and morale; risk analysis and decision theory; conflict resolution and avoidance; arbitration; status transmission and reward systems; and many other such fields of inquiry. Unfortunately, these fields lack meaningful university-industry interaction because of a minuscule industrial resource base. However, stronger industry advocacy for federal R&D support for the social and behavioral sciences would emerge if investigators would actively pursue dialogues with industry and seek out their requirements for these disciplines.

In summary, I believe there is still a great deal more that industry and government can do to meet current impacts of federal policies on R&D, even while adjusting to current national economic policies and federal budget realities, which are overriding. Attempting to be too rigorous in delineating the respective roles of the federal government and the private sector in supporting science and technology is a sterile exercise. On the one hand, it's a choice between direct versus indirect allocation of resources; on the other, it begs too precise a partitioning of shared responsibilities.

D. V. D'Arbeloff

I do not believe that I am unique in my firm conviction that technology is this country's most important competitive strength in world markets. The Japanese have clearly demonstrated that their management, manufacturing, quality control and marketing techniques have been superior to ours in the markets they have successfully penetrated. We are responding and, in the not-too-distant future, we can correct many of our deficiencies. Technology, however, has long lead times and, in the private sector, we find ourselves in a continuous conflict between short-term financial performance and long-term investments in research and development.

Recent changes in our tax laws (R&D tax credits, equipment donations) have helped, but are really lip service to the more fundamental issue -- a clear public policy that encompasses financial incentives for industry, basic research in universities and other non-profit institutions and the availability of technical human resources. The latter could be the most critical issue, since companies like mine can grow only if we can attract the technical people we need and if the universities are equipped to educate them.

Translating the problems into solutions that lead to effective public policy is a slow process. However, educators, industry and government should recognize the urgency of the situation and join forces in at least defining the issues.

There are a number of organizations that I am associated with that are attempting to formulate a comprehensive position aimed at public policymakers.

In the interim, there is much that the private sector can do. I will ask your indulgence and talk briefly about the Massachusetts High Technology Council, of which I am chairman, and what it is doing about the quality of science and engineering education in Massachusetts.

For those of you who might not be familiar with the High Technology Council, we are an association of 125 high

technology companies. Most of our members can be characterized as growth-oriented, high value-added, knowledge-intensive companies that spend proportionately large amounts of money on research and development, and depend primarily on high technology for their products and services. We employ about 115,000 people in Massachusetts and about 85,000 more throughout the rest of the world. Sales world-wide last year totalled about $11 billion and we invested almost $2 billion in new plant and equipment -- up 36 percent from 1980.

It is the high technology industry, more so than any other, that has carried the New England region through the latest flux in the economy. We've slowed down quite a bit, to be sure, but the "help wanted" pages of the Sunday papers are still filled with high technology ads looking for engineers and computer scientists.

However, we are starting to suffer from our own success. The reason so many skilled positions remain unfilled is simple -- the supply of technical talent has finally been outstripped by industry demand, and this problem is not peculiar to Massachusetts.

Nationally and regionally, the systems for educating engineers and computer scientists are at saturation. Since 1975, the number of degrees awarded in engineering has ballooned by 50 percent, and many students interested in studying engineering and computer science are already being turned away due to lack of faculty, equipment and resources.

MIT president Paul Gray spoke at a conference we held in February on engineering education. He pointed out that even MIT, one of the most prestigious engineering schools in the world, is having trouble attracting qualified faculty. Nationally, nearly 20 percent of all engineering faculty positions remain vacant, and the chief stumbling block is money.

Entry-level engineers with a bachelors degree in engineering can make more working in industry than an assistant professor with a masters can make working in academia. The equipment in industry is better, the opportunities to do applied research are better and the staff support, for the most part, is more experienced.

The problem does not begin at the post-secondary level either. Today, only one high school graduate in six has studied more than one year of mathematics or science.

Simply put, this country could not be doing a poorer job of preparing its young people for the technologically-oriented world of tomorrow. The ramifications of this go far beyond mere socio-economic concerns, for the countries that strive to develop a technically literate populace will prosper, while the rest will not. As I indicated earlier, it is up to the high technology industry, government and education -- on all levels -- to work to alleviate this problem, and we do not have much time.

The High Technology Council has run an active human resource development program for several years, implementing a number of projects to help expand capacity and improve quality over the short-term. We have established electronic technician training programs in our community colleges for technical paraprofessionals, stepped up recruiting efforts at out-of-state engineering schools and worked with the state and community college system to initiate technical writing and computer programming courses for former school teachers who have been laid off due to declining enrollments. One further note on this -- in 1995, we are projecting 46,000 high school graduates in Massachusetts. In 1979, we had 79,000 high school graduates.

To help, over the long-term, we recently developed and formally endorsed a "white paper" on university-industry relations, geared specifically toward expanding engineering and computer science education opportunities and improving existing curricula.

Specifically, there are eight points:

(1) View support for higher education as an investment in human resource development and not as a charitable contribution.

(2) Increase member companies' support for higher education in 1982 to 2 percent then sustain that support on an annual basis for the foreseeable future.

(3) Continue to identify and replicate collaborative activities that already work well and work to implement new ones.

(4) Plan for the future by working with universities to develop what are likely to be more relevant curricula and research projects.

(5) Recruit more professionally and more actively at regional colleges and universities and sustain recruiting programs in lean years, not just in growth years.

(6) Develop new, and expand current, jointly sponsored programs in continuing education with universities. In the future, "learn while you earn" will be the norm and not the exception.

(7) Become more visible and more active as supporters of elementary and secondary education: promote high tech careers, stress the importance of computer literacy, help strengthen math and science curricula, and work to improve teaching methods and techniques.

(8) Continue to encourage the state government to increase its support for higher education, particularly with regard to technical education.

Not surprisingly, the 2 percent of R&D support for higher education has attracted the most attention. In fact, many news stories and editorials have adopted it as "the 2 percent solution". In Massachusetts the 2 percent represents a minimum investment of $15 million per year in higher education in Massachusetts -- just from our 125 members.

The Council, however, is not serving as a foundation or central money fund. Instead, we act as a facilitator and clearinghouse -- bringing individual companies together with colleges and universities, so that they may develop mutually beneficial one-on-one relationships that involve more than just financial assistance and equipment donations.

We help both sides help each other when necessary, but we prefer to let the companies that are donating the time and money work directly with the educators.

Many of our members are already involved in university-relations programs, but we are strengthening the relationships and elevating their importance. Millipore, for example, has taken the university program out of our corporate contributions activity and has made it the responsibility of our technology planning board, headed by the president of the company.

Some of the programs our companies currently participate in include:

- Career Development Faculty Chairs -- A company finances salary and equipment costs for a new or expanding high technology program at a college or university over an extended period of time, improving the quality of academic life for the professor and the quality of technical education for the students. Analog Devices, Digital Equipment Corporation and Hewlett-Packard, to name three, have all become very active in this area.

- Adjunct Professorships -- Companies "loan" employees to colleges and universities to teach courses in their chosen fields of expertise once or twice a week. Data General, for example, has two employees teaching at Lowell University on a part-time basis.

- Curriculum and Faculty Development and Assistance -- Companies help schools expand or improve technical curricula by providing technical assistance and company training programs. Lowell University, for example, has three professors enrolled in training courses at Data General. Millipore is initiating a comparable program with MIT.

For example, our Council published a guide for universities interested in developing computer science and engineering programs. It deals with the skills and knowledge the graduates must have if they are to qualify for the many different employment opportunities in our companies. Also, women who have math or science backgrounds, but lack technical degrees, are presently earning masters degrees in a new "Women in Engineering" program, facilitated by the High Technology Council, and sponsored jointly with the Bay State Skills Corporation and Northeastern University.

- Learn-While-You-Earn and Continuing Education -- Our companies are offering part-time consulting contracts to engineering and computer science masters and Ph.D. candidates to encourage them

> to go on with their education by alleviating some of the financial pain that accompanies that decision. We've also developed retraining and continuing education programs with colleges and universities that can be used to bring employees up to speed with new technology.

These are a few things we are working on and, for the first time, it's being done in a coordinated fashion through the Council.

Recently, however, the state government and a number of educators have begun to take a more pro-active role as well. One initiative in Massachusetts that has the potential to combine the expertise of all three groups is the proposed High Technology Park Corporation. Its first project, a multi-million dollar microelectronics center, will help educate students and working engineers in advanced semiconductor design, test, and fabrication techniques, and will be staffed by participating university faculty and loaned industry professionals.

The High Technology Park has been proposed by Governor King's administration and has the support of many members of the state legislative leadership. It represents a three-part strategy to strengthen the microelectronics industry in Massachusetts by offering:

(1) An up-to-date lab facility for our engineering and computer science students and faculty;

(2) Comprehensive retraining and upgrading programs for industry employees; and

(3) A chip-making facility that will give students and faculty a chance to see if their designs really work. The initial contemplated investment will be split by the state and the high technology industry on a 50/50 basis.

Another program that has been supported by industry is a new kind of M.B.A. program at Northeastern University in Boston. Starting in September of 1982, Northeastern's School of Business Administration will offer a specialized and accelerated M.B.A program in high technology. The first of its kind in the country, the degree program consists of

twenty-eight courses and sixteen new or redesigned courses, specializing in topics like technological forecasting, R&D management, and new product management.

The program is geared to train technically-oriented engineers, scientists, computer and technical specialists, and high tech managers, and it will meet at night, thus allowing professionals to continue to work while attending school.

We have been heavily involved in the planning and implementation of both of these projects and will probably contribute substantial financial assistance to the microelectronics center if equipment donations and research work can be credited or deducted. Its status as an educational institution is unclear at this point.

In the last analysis, the future of the high technology industry will depend, to a large extent, on this country's ability to grow and sustain a proficient technical work force. It should be remembered that this is no longer an issue that can be addressed independently. Instead, all three pieces of the puzzle -- industry, education and government -- must play active roles if we are to succeed in this critical endeavor.

One essential step, but certainly not the only one, to develop a strong technology-oriented populace, would be to encourage initiatives which would improve computational skills for students at all levels. Along with this would come a greater familiarity and literacy with analytical tools like the computer, making it possible for them to function more successfully in society as it exists today -- and as it will continue to evolve into the future.

Nothing less than the socio-economic future of the next generation -- and America's position as a world leader in all fields -- is at stake, for to be technologically rich is even more valuable than to be oil rich, because technological creativity is inexhaustible.

Perhaps what we are doing in Massachusetts is a microcosm of what could be done throughout the country through industrial initiatives. There is little doubt in my mind that the best way to educate the public sector is to lead by example.

George R. White

Xerox is such a vital institution that I think everyone in the audience should realize that my views are prejudiced by my nearly 20 years of experience at Xerox. I really cannot be seen as representa ive of the private sector. In fact, the first point I'd like to make is that I do not believe in the private sector. As debates in Washington discuss what the public sector should do and the private sector should do, I'm distressed by the singular. There are very many private sectors.

The sector that Xerox represents is the private sector that's deeply engaged in the information revolution. This is clearly going to be the most important business event of the last half of the 20th Century, and very likely may be the most important cultural event as well. Our company currently spends more than $500 million a year on R&D, basically all in areas of information technology. Our budgets are increasing dramatically every year, far faster than inflation, and significantly faster than probably any other single component of our company's financial makeup. We are long-range investors in R&D. The superficial point of view that says American business has trouble because it's myopic is just that: superficial. Our company does have some problems, thank you, but they do not come from a short-range focus on the importance of R&D investment.

The last point I'd like to make about Xerox -- because it gives me fundamental trouble for the context of this conference -- is that our company is truly multi-national. About 47 percent of our revenue comes from world-wide operations outside the United States. For example, we will introduce major products within the next year where the R&D was done the United Kingdom, the United States, and in Japan. Our Xerox center for materials science and materials process research is the Xerox Research Centre of Canada. A conscious decision on our part has worked out very well; the most favorable location for our corporation to master that particular set of arts was in the Canadian economy and in the Canadian educational system.

At Xerox we cannot approach or totally respond to the theme of this conference as one of the national crisis in R&D

in the United States. (And of course the competition itself is also multi-national and international.) The frame of reference in which we think is not congruent with many of the remarks made at this conference. R&D has been critical to the emergence of our company. It was very long-range investment by a small predecessor, Haloid, and continuing long-range investment that led to the xerographic successes.

The problem we have now is that everyone in the world is convinced, as we are, that the information revolution is coming, and they are investing in long-range research, as we are, to get a lion's share of the benefits from the information revolution. So the question is not the simple question, "Do you invest in the future of electronics and software and information systems?" because the answer is, "Of course you do." Everyone does. The question is, "How well do you do it?" It's not a question of how much. It's a question of how well.

Now, with that as background for my biases, what I would like to take you through is my analysis of the three most important positive factors in expansion of industrial R&D at the present time, as seen from the point of view just elaborated, and also the three most important negative factors. It is policy in Washington and policy in corporate headquarters on these causal factors, rather than simplistic thermometers as to whether budgets go up or down, that determine how well our company -- or, if your focus is national, how well the United States -- will do in this single most critical area.

The first and strongest factor for expansion of industrial R&D, in the areas our company cares about, is the expansion of the information systems market itself. Industry is very responsive to market pull, and the stronger the markets are, and the more accurately they can be projected, the more valid it is to invest in R&D.

The single biggest stimulus resulted from a beneficial decision made in Washington, with great difficulty. That was the decision to deregulate the U.S. telecommunications industry. We all know how excellent the Bell Laboratories are and have been. We also know that there was no other U.S. telecommunications laboratory operating at anywhere near their quality or scope. We are going to find out whether a whole industrial sector -- instead of only one firm -- can benefit by having prime access to the telecommunications market. As far as our company is concerned, and as far as national policy is concerned, the posture is very clear: we think there will be many more beneficiaries by deregulating telecommunications.

Another major stimulus in expanding the markets for information systems is expanding acculturation and new uses. We all understood what a computer room was ten years ago. But as leisure computers, hobby computers, small business computers, and the personal computer market arise, no one understands any longer what is a computer room. Maybe it's a family room next to the TV. Maybe it's a teenage daughter's bedroom. Computers are showing up much more richly culturally than they had in the past, and there's no possible consequence of that except dramatic expansion of the market because of confidence and interest, as well as applications.

A further stimulus in expansion of the information systems market is the rise in investment, and the understanding of software as a special activity. Software had always been considered an adjunct to the computer hardware manufacturers' marketing program. The rise of an independent software industry -- the fact that the easiest business for pure intelligence to enter, with the least reliance on capital equipment, is software -- is terribly invigorating to a wide variety of people who wish to pursue new subjects, new applications, and new techniques. Now software is the critical glue for information systems and the better we get at that, the more we understand about that, the better off all of the users will be.

The second major factor for industrial R&D is the continuing reduction in the cost of micro-electronics. I'm not going to dwell on the fact of the costs decreases; it's well understood that they stem from increased density per chip, adding more function for no more material or process costs. But a subtle advantage is the predictability. You can draw a semi-log plot of the cost per thousand or the number of transistors per chip on graph paper. With essentially no variance over the last ten years and over the next ten years, we know what those costs will be -- radically decreasing at rates from 25 to 30 percent per year, in an economy bedeviled by inflation. It's the only major industrial technology that has that large and that predictable a cost reduction.

The consequence of this, of course, is that my wristwatch doesn't tick anymore, there are no slide rules, and the R&D increase does not come only from micro-electronics itself. For every product and every service that one can imagine there's a crossover line when the electronic variant becomes more cost effective and provides new opportunity -- from automobiles to home games. So there's a tremendous secondary stimulus to R&D in other areas by the penetration of the micro-electronics cost decreases.

The third major factor for expansion of industrial R&D is heightened international competition. I think that comes in several flavors. We've mentioned many times in the meeting today Japan Incorporated, or the Japanese success as mass manufacturers of products sold on world markets. The penalties for not succeeding on a timely schedule to bring new product innovation into the marketplace are now more severe than they were 20 years ago. All enlightened and vigorous managements are recognizing that they can win if they do their R&D, and they can lose if they don't. The second half of that challenge was not as strong before as it is now.

A second element in the heightened international competition is the invigoration of industrial policies driving R&D investments around the world. In almost every other country except the United States, industrial R&D is a ministerial concern rather than a corporate board room concern. The national government worries seriously how to allocate the monies, and even provide the monies, that support the industrial R&D of that nation.

The third element of force in this heightened international competition is the internationalization of markets. As the new technology damps and swamps out what had been cultural differences, we find that products have much less national flavor. A large digital computer supporting OS360 and its derivatives (the IBM software literature) is now the key element in the Japanese computer industry and the German computer industry, as well as in the United States computer industry. Word processors and electronic office equipment from Olivetti look remarkably similar to equipment from Japan. The internationalization of these markets, like the internationalization of the automobile market, says there's more to gain if you win and more to lose if you don't.

Now, with all of those positive benefits, enlightened managements may be justified in spending more money and making more intense commitment to R&D. But are there any compensating negatives? I hope they don't compensate, but there are some negatives. (For parallelism, I'll stick to three.)

The first factor is the rise in protectionism. Protectionism is disastrous for research and development. Whoever has the lion's share of the marketplace behind a protectionist wall is insulated from competition and need not innovate, which means he need not do R&D at the pace that had been done before. He has legal barriers rather than excellence and achievement as his defense.

Secondly, protectionism decreases the scale for returns to R&D investment. If one can sell the products of R&D in only one nation rather than the whole developed and developing world, the justification for R&D stops at a lower level.

Finally, the third -- to me a subtle but important point -- protectionism requires the active tending of protectionist barriers by government operations and government policy. To get the government deeply enmeshed in the details of research and development is, in my view, stultifying. One of the most protectionist ideas that I've heard in a long time is the concept that's being advanced (in my view, as a false solution) to our defense problem: How do we make sure that we deploy much stronger technology than the U.S.S.R. does? The concept that is inherently, ultimately protectionist is to draw a fence around the United States and keep any flux of technology through that fence at zero. Well, I dare say no one has done a careful analysis of what the influx is as well as the outflux. If we keep that flux at zero for a long time we will not have international technology leadership.

The second major negative factor for industrial R&D is the one that's been mentioned several times in the course of the meeting: critical shortages in key skills. Now it is absolutely statistically true that we will have inadequate cohorts of new graduates from universities in critical areas. Regardless of whether one analyzes the number of students in the demographics, or the number of professors and competition for their services, there are simply not going to be enough 21 through 25 years olds coming out of the universities to fill all of the spots in the high technologies I'm concerned about in the United States. The consequential volatility of the R&D establishment, inadequate staff to handle jobs, job hopping, shifting around, and so forth, is the antithesis of stable and effective personnel policies and institutional development for crackerjack R&D.

I just want to parenthetically say that I was terribly impressed by the Massachusetts high-tech account that you [D'Arbeloff] gave; everything you had in your list is right. The one I care the most about is serious commitment by first-class educational institutions to retraining. The trends in the United States say that there will increasingly be a much smaller number of young workers, and a much larger number of older workers. In fact, we've legally extended the horizon for work to age 70. We cannot afford to waste decades of contribution of workers by pretending they cannot learn anything that had not been invented by the time they were 23 years old.

At the present time our educational establishment relegates night school and extension education to second-rate or even third-rate educational institutions. The first-class universities of this country are, by and large, not interested in new selection, new certification, new training and new validation of mid-career upgrades on the part of serious and experienced people. I think that's unacceptable. Industry is much more willing, in my view, than the universities are to walk that extra mile so a man or a woman at 35 years old can come out with the same kind of educational experience and impact that a 21-year-old can. It requires some changes in institutional structures to make that go right.

The third and the last of the negative factors for industrial R&D is perhaps the most obvious, though I put it in third place in priorities, and that's simply the persistent deterioration of R&D economics. Industrial R&D is not a focus of national needs. An industrial R&D program is a focus of individual corporate opportunities. And if our economy is in trouble, our R&D is in trouble. So, the gross macroeconomics of the United States has to be healthy for industrial R&D to be healthy.

Beyond that general statement, which is quite important, R&D salaries -- partly because of the shortage of trained, effective people -- have been escalating faster than almost anything else you can find an index on. The facilities and equipment to support modern R&D have also been escalating very rapidly. So, on a constant manpower basis, our corporation, as most corporations do, keeps track of its R&D budget and, as I said earlier in the talk, they are perhaps the fastest growing element in terms of index of inflation in our whole corporate accounts.

I'd like to finish by making three summary statements relating to the point of view I've tried to communicate. An information systems revolution will occur. That is absolutely predestined. Whether its primary beneficiary is the United States as a nation depends almost completely on industrial R&D in the United States, not on government R&D and not on university R&D. The two leading institutions that we have in this area are the Bell Laboratories and the IBM Corporation. We have just recently -- in fact with the change of administration -- decided that we would welcome them back to the fold as valid institutions in their form and in their function, rather than as adversaries of our official government policy. Very important issues are wrapped up in that.

Second summary comment: a healthy industry will fund and will rely upon industrial R&D. It is the opportunity of the industry, not the obligation of the industry, that determines how much R&D is done in an industrial context.

And third: protectionism, lack of adequate skills, and general stagflation in the economy, as inputs to the R&D management picture, are far more important issues for the federal government to worry about than the details of the direct government funding of R&D programs and studies.

Daniel Adams

Today I will speak about my experience in the formation and management of high technology companies which are seeking to exploit recent developments in genetic engineering, and how I perceive these companies will affect the research and development establishment in the United States and elsewhere.

As you may know, my experience with genetic engineering companies dates back to the mid-1970's when, as a venture capitalist, I became convinced that genetic engineering ultimately would prove to be the most important technology for the remainder of the twentieth century. I invested in Cetus and Genentech, both at an early stage, and co-founded Biogen. In 1979, I founded my current company, Advanced Genetic Sciences, Inc. (AGS), which is today a leader in applying advanced microbiological techniques to the improvement of agronomic plants and plant biosystems. The company's research and development activities are directed by a scientific board of seven top scientists from five countries. It has laboratories in Belgium, California, Kansas, and Finland, and executive offices in Greenwich, Connecticut.

Most of my attention will be focused on the companies I was instrumental in founding, Biogen and AGS, basically because these companies are employing an approach to research and development which I believe is unique.

The incentive to form Biogen and later AGS grew out of my concern that industry was not making very good use of the world's best scientific talent. Over time I had become convinced that the traditional corporate consulting relationships established with these scientists and so-called scientific advisory boards were not effective ways to use their talents, nor were these vehicles particularly effective in fostering technology transfer. An in-depth discussion of why these relationships do not work as well as they might would take much more time than is available today, and therefore I will attempt to summarize some of the reasons. First, from the corporate side, effective use of top scientists has been impeded by a reluctance to provide

the consultants or advisors with the "full deck" of corporate information and know-how they need in order to effectively aid the corporation in its research programs. This apparently occurs because of concerns about the wisdom of disclosing important corporate information to people who are not "committed" to the corporation. University scientists were, and often still are, regarded as "egg heads" who are suspect because they are not motivated by the factors which motivate the corporate scientist.

From the standpoint of the university scientist, the traditional consulting relationship does not establish a feeling of commitment to the corporation, partially because of the method of compensation, and partially because of the lack of responsibility for decision-making, and, consequently, credit for success or responsibility for mistakes. After I discussed the matter with many university scientists, it became clear that they found consulting with commercial enterprises frustrating because they were left out of the decision-making process. The scientists expressed little desire to run the company (although recently some, such as Walter Gilbert, have changed their minds), but they were reluctant to invest a substantial amount of time and effort in a project and then be left completely in the dark as to how their work was used.

As an aside, I should point out something you all know -- that not a few so called "advisory boards" are established to in effect exploit the names and reputations of the members, a use which hardly promotes the advancement of science.

An alternative use of senior scientists employed by companies such as Monsanto and Hoechst is to fund major projects or entire activities at important universities, where the sponsor retains rather unspecific rights to negotiate for patents, if any, arising from the laboratory or activity. However, funding alone does nothing to change the way research is conducted at the university. Thus, the traditional concerns of corporate research directors about university scientists remain: lack of incentive to undertake projects which have commercial potential, lack of incentive to pursue patents or to carry out a project in a way that will lead to a patentable development, and lack of continuity among research personnel. While this university project funding may be extremely beneficial to the university, and therefore I encourage its advocates to carry on, I seriously doubt the proponents of this approach can justify the investment on the basis of return to the corporation.

Given this background, the challenge obviously was to find a way to establish an organization which could fill the gap I perceived between the traditional corporate approach to research and the university approach; in effect, trying to combine the best elements of both. What was apparent was that (1) it would be necessary to create an atmosphere at the scientific board such that the top scientists we recruited to serve on that board would develop the necessary sense of commitment to the enterprise, and (2) our own corporate laboratories would have to be "open", in the sense that research would be carried out in such a way that the enterprise could build a profitable business. Of course, this meant the research environment had to be such that the enterprise would be able to protect its development. This problem was particularly acute because I was convinced that development companies such as AGS could only compete effectively with their more established and wealthier brethren if they were able to attract and retain a consistently higher level of research scientist over a substantial period of time. The young scientists we hoped to attract to our laboratories were in general dubious that they could pursue research of interest to themselves in the corporate environment, could publish their findings so they could maintain their standing in the scientific community and could continue to collaborate effectively with scientists working in other laboratories. In general, they wanted an "open" laboratory where they would continue to be free to "trade" knowledge so they could keep up to date on current developments. Many people believed that the conflicts could not be resolved, but after many months of reflection I became convinced that an enormous opportunity was present and solutions were there. Biogen and later AGS were formed to put into practice our new approach to research.

A major departure from standard practice is the way in which AGS uses its scientific board. This board meets frequently to establish the overall scientific direction of the company. It also reviews and directs (from a scientific standpoint) ACS projects both in its laboratories and at other locations, and is responsible for identifying and recruiting scientists for the company's laboratories. Thus, the AGS scientific board performs one of the most important line mangement functions for the company. This is the primary way in which our use of a scientific board differs from the general use of scientific <u>advisory</u> boards as I discussed earlier.

How does the scientific board function in practice? Members of the scientific board are located at an AGS research facility or remain at their academic institutions.

Each member not located at an AGS facility carries on in his laboratory at least one project which has commercial aspects of interest to AGS (assuming, of course, acceptable arrangements have been negotiated with the scientist's institution). All AGS projects, whether carried out in a scientific board member's laboratory or in the AGS laboratory, have been approved in advance by the scientific board, one of whose members assumes responsibility for it. The supervising member arranges a presentation on the project at each meeting.

The decision on funding an approved project is made by the board of directors, but the scientific board has representatives on the board of directors. It is their responsibility to represent the scientists and to report to the scientific board on decisions made by the board of directors.

In order to further enhance the sense of commitment to the corporation and to insure that the scientists will participate in the success of the enterprise to which they are devoting a significant amount of time and energy, each scientific board member becomes an important shareholder in the company. The bottom line is that through participation in management and ownership of the enterprise, senior scientists have been able to reconcile most of their concerns about interactions with corporate life.

So much for what one might call the scientific "big guns". We were still faced with the problem of how to attract and retain a constantly higher level of scientists to our research laboratories than our well-heeled competitors. Of course, the ability to work with people of the stature of the members of the scientific board was a real attraction. But more was needed to resolve the questions of scientific interaction and publication.

On interactions, it occurred to us that laboratory location was important. AGS has several laboratories, all of which are located near university research centers which are carrying out work of importance to AGS and with whom AGS has established good working relationships. It seemed to me that there was little or no advantage to locating corporate laboratories in "ivory tower" settings far from centers of learning, except to cut off the researchers from the rest of the scientific community and, in effect, limit their and their families' associations to other company employees. In view of the considerable value of the scientific "grapevine" and of a scientist's interaction with other scientists, the "ivory tower" setting appeared to be counterproductive. We

also decided that it was supremely important to attract the highest calibre of scientist for whatever period of time the scientist might be available rather than to stress the "permanent" employee. Therefore AGS uses postdocs extensively in its laboratories.

Industry-university relations have been dealt with at length in earlier talks and I will not dwell on them further except to say that our approach is pragmatic, and once the current period of unrest and insecurity passes we believe our approach will prove to have been the right one.

The issue of publication at first blush appeared to represent an irreconcilable conflict between the researcher and corporate needs. However, after discussing the matter with many people I became convinced that the problem was caused primarily by lack of communication between patent attorneys and scientists, and a lack of incentive for the attorneys to say "yes" to a publication or to respond quickly to such a request. Further, I was convinced that any loss from having an "open" laboratory would be more than offset by the gain from the "grapevine" input and from our ability to attract the better scientists to open laboratories. AGS encourages publication of findings of general scientific interest and provides the means for its scientists to get their manuscripts into press. It has organized its patent regime in such a way that publication will not be held up by patent considerations. If our lawyers cannot respond effectively, we get new lawyers.

I suppose you are wondering whether the expectations for the bioengineering companies are over-inflated. To answer this question, I have to know whose expectations we are talking about. Somehow certain elements of the investment community came to believe and may still believe, that the laws of gravity have been repealed for bioengineering companies. I am aware of no such event. I am, however, aware that a fool and his money are soon parted (sooner in the case of those who invest in ill-conceived bioengineering companies), and so has it been with those who throw their money at anything that has genetic engineering in its name. Southern Biotech, for example, issued a prospectus indicating a desire to produce and market interferon using outdated methods. In my opinion, the underwriters should have been able to determine that there could never be a market for this product once cloned interferon became available, and they also should have been aware that the funds ultimately raised in the public offering were wholly inadequate. All this was obvious to me from reading the preliminary prospectus and should have been obvious to others.

The survivors in bioengineering, as in any other field, will be those who capture the best scientists from a limited pool of talent and who evolve a workable, believable concept which gives them a competitive edge.

The questions remain as to whether the organizations I described are beneficial in the short or long run to the advancement of science. While the jury is still out, it seems to me that the answer ultimately will be in the affirmative.

Some have argued that the new bioengineering companies are stripping the universities of their best people. Whether this is true, and if so whether it is as a result of the attractiveness of the companies or the state of funding for research in the United States (both from the standpoint of reduction in amount and the "price" one has to pay to obtain federal grants) is open to question. On balance, I would argue that the primary factor is the state of funding and, I would add, the increasing awareness of scientists in general of attractive alternatives to many of the frustrations they have in dealing with university and federal bureaucracies. If a drain is occurring, it is for the universities and funding agencies to deal with it by reshaping their policies.

What impact are companies like AGS likely to have on the competitiveness of U.S. science internationally? I can only surmise the impact will be beneficial if we have in fact established a more effective way in which industry can relate to the country's best scientists and we are providing a more attractive (i.e. stimulating) environment in which scientists can work. If we have not done this, then we will of necessity fail.

AGENCY PERSPECTIVES: DEPARTMENT OF DEFENSE

Moderator:
Rodney W. Nichols *(Chairman, AAAS Committee on Science, Arms Control and National Security; and Executive Vice President, The Rockefeller University)*

Speaker:
Leo Young *(Director of Research and Technical Information, Department of Defense)*

Agency Perspectives: Department of Defense*

Leo Young, director of research and technical information at the Department of Defense (DOD), opened the session with a few remarks about DOD-university interaction. Universities perform 47 percent of DOD's basic research (budget category 6.1, entitled simply "research" by DOD). This percentage will probably increase, since statutory staffing constraints at government labs limit their expansion to the inflation rate. The result is that the level of DOD-sponsored university research increases at a rate almost double that of research overall above inflation. Thus while research funding will increase 19 percent from FY 1982 to FY 1983, research at universities will increase some 24 percent (assuming 7 percent inflation). Young also noted that DOD believes that research and education are closely connected, since teaching a new technology to a graduate student who will then go out and work for industry is one of the best ways to transfer technology.

DOD is working to improve its relations with universities in other areas as well. It plans to spend $150 million over five years to improve university research instrumentation. There was considerable audience interest in this program. The program guidelines are still being formulated, Young said, but DOD will ask for proposals of two types: new R&D of interest to DOD which requires new instrumentation, and existing R&D of interest to DOD, however funded, which could benefit from improved instrumentation. The instrumentation required should be in the $100,000 to $1 million range. Less expensive equipment is covered by existing grant programs and research contracts to the order of $30 million per year. The program is not for computers as such, except as they are used in operating instruments. DOD will circulate a long list of technologies of special interest to it.

*Note: Summaries of the "agency perspectives" sessions have been prepared from notes taken by staff at the sessions. They have not been reviewed by the speakers.

DOD will also increase the number of DOD graduate assistantships. The Office of Naval Research supports forty graduate students in a program similar to the NSF graduate fellowships. The Army and Air Force have a handful of programs for specific purposes, although Young is trying to persuade them to adopt programs similar to NSF's. Although growing, these programs are still small compared with the four thousand graduate students supported through research contracts.

Young also explained some of the details of the DOD-University Forum. It consists of ten high-level people from universities and ten from DOD who meet twice a year for a few hours. There are currently three working groups, in export control, science and technology education, and foreign language and area studies. These groups carry out the bulk of the Forum's work between meetings. Discussions are frank and wide-ranging. The Forum should not be confused with the Defense Science Board, which is a panel of distinguished scientists and engineers who provide technical advice to DOD.

In response to a question Young said that DOD was helping to support engineering faculty through summer research, consultantships and similar programs. With regard to the foreign lang age problem, Young agreed that there is a pressing need for foreign language proficiency in this country. While DOD has no plans as yet, it will do whatever is necessary if Congress allows it to.

Young also answered several questions concerning basic research. The FY 1982 - FY 1983 increase in research is 19 percent, compared to a total increase of 21 percent for Research, Development, Testing, and Evaluation (RDT&E) as shown in Table 1. These numbers show that basic research is important in DOD but not exceptionally so. There is more emphasis now on getting things out onto the field, which means the development side of R&D is seeing the largest increases. The RDT&E budget categories are quite strict; the services cannot reprogram among them. With the large growth in defense R&D, DOD has picked up a few formerly civilian projects, but DOD is a mission agency. Congress would probably frown on any DOD attempts to fund programs which had been cut elsewhere, he said, adding that there has been some talk with NSF and DOE, for example, but no active consideration of picking up their civilian programs.

There was considerable discussion of independent research and development (IR&D), which is company-initiated R&D funded considerable sum, about 3 percent of the total value of these procurement contracts. The idea behind the program is for DOD

Table 1. Department of Defense FY 83 Research, Development, Test and Evaluation (Budget Authority in Millions).

	FY 82	FY 83
Research	$ 695	$ 828
Exploratory Development	2,213	2,509
Advanced Development	3,476	4,689
Engineering Development	7,683	8,919
Management and Support	2,009	2,224
Operational Systems Development	3,968	5,088
TOTAL	$ 20,044	$ 24,257

to pay for general development and overhead costs which are associated with a project. The yearly amounts are not set ahead of time, but in FY 1981 the 100 largest companies performed $4 billion of IR&D, of which $3 billion was reimbursed by the government (90 percent by DOD). Of this, $1.3 billion was for bid and proposal costs, which are research costs incurred while developing procurement proposals. DOD hopes to stimulate industry to use universities as performers of IR&D in order to improve university-industry ties. The exact mechanism for this is still being discussed, although Young favors reimbursing 100 percent of IR&D performed at universities, instead of the usual 75 percent. IR&D is a very sensitive issue with manufacturers, so DOD will suggest, rather than mandate, that industry perform some IR&D at universities.

There were several questions concerning restrictions on research. In the past, foreigners could not work on DOD or AEC projects, even if they were unclassified. Now there are no restrictions on who may work on projects in the research (6.1) category. As yet there has been no decision concerning the use of equipment paid for by the new instrumentation program, but Young felt that there probably would be no restrictions. Although there has been substantial discussion regarding prior review of articles arising from DOD-sponsored research, Young said he considered it highly unlikely that any such prior review would be implemented.

Half of DOD-sponsored university work is in the research (6.1) category. All contracted research in category 6.1 is unclassified, so this part of university work is entirely unclassified. Most of the rest is also unclassified. Almost all classified university work is done in off-campus institutes; only one university does classified work on

campus. The real secrecy dilemma, though, is not classified versus unclassified work, but research in sensitive technologies. These are technologies whose primary applications are commercial but which are also important militarily, such as integrated circuits. DOD is concerned that sensitive process knowledge is being exported to various countries from which it can be obtained by unfriendly countries. This is a topic of active debate within DOD.

In response to a question, Young said that the Small Business Innovation Bill could be potentially disastrous to research. The formula in the original Senate bill would have required 20 percent of the research (category 6.1) budget to go to small business, while the original House formula would have required almost the entire budget. The later and more likely versions protect the 6.1 budget so that just one percent would be earmarked for small businesses.

After remarking that budget figures for periods further ahead than two years were largely fictitious, Young responded to a concern that large increases in DOD R&D budgets would result in inefficiencies. He pointed out that expensive duplication is highly visible, and that the services each review the others' research projects. Additionally, he pointed out that after accounting for inflation and the instrumentation program, as well as for the proposed House cut, there is only a 4 percent real increase in category 6.1, which is certainly manageable.

The final question concerned conflict resolution. The questioner pointed out that "technology creep" tends to be destabilizing, and wanted to know whether DOD would use the social sciences to develop non-military methods of resolving conflicts. Young answered that DOD was a mission agency, and that its social science research revolves around training methods. Moderator Rodney Nichols mentioned that the State Department has a small budget for conflict resolution research. In the past Congress has frowned upon DOD forays outside of its primary military mission.

AGENCY PERSPECTIVES: DEPARTMENT OF ENERGY

Moderator:
Shirley M. Malcom *(Head, Office of Opportunities in Science, AAAS)*

Speaker:
Joel A. Snow *(Senior Science Associate, Office of Energy Research, Department of Energy)*

Agency Perspectives: Department of Energy

Joel Snow, senior science associate with the Office of Energy Research, began by addressing the current status of the FY 1983 federal budget. The lengthy process that culminated in the submission of the President's budget was only the beginning of another lengthy process. The just-passed congressional budget resolution is still a long way from actual expenditures by the federal government. Although the resolution sets broad targets by functional area, within which the appropriations committees are supposed to work, they are perfectly free to propose bills that are inconsistent with the budget resolution. Consequently, Snow said, it is not very useful to discuss budget details.

Snow noted that although the administration had proposed major changes, primarily reductions, in the Department of Energy (DOE) budget, the budget resolution would restore all the DOE programs to roughly their FY 1982 levels. Thus conservation and fossil R&D will not be eliminated. General science programs, however, are funded almost exactly as in the President's budget. There is a healthy increase for high energy physics, a level budget for nuclear physics, and a substantial reduction for basic biological research. Overall, though, the will of the Congress seems to lie not with the budget the President proposed but with the budget Congress itself established last year.

The focus in this administration, Snow noted, as accurately described in the AAAS R&D Report, is on research rather than demonstration and development. There is clearly a belief that the Carter Administration overreacted to the energy situation and pushed things forward too fast. Snow paraphrased a current television commercial for wine, saying that the Reagan Administration's view is "we will back no technology before its time." The private sector will have to decide when to push something onto the marketplace. The federal government has returned to its traditional R&D posture

of supporting long-range, fundamental research which is not really appropriate to any particular company but is needed for overall economic and social development.

The difficulty, of course, is determining where the boundary lies between the proper federal and private sector roles. The boundary has to be drawn differently in an area like enhanced oil recovery, where there are companies such as Exxon and Occidental operating with substantial available capital, and in an area such as controlled fusion, where the potential payoff is so far downstream that no company will invest in it now. Snow said priorities and boundaries must be set on an area-by-area basis, and DOE has the Energy Research Advisory Board (ERAB) to do exactly that. Its report of last November, Federal Energy R&D Priorities, was somewhat notorious, but Congress's budget is much closer to the spirit of the report than the President's budget was. ERAB acts as a sounding board for the scientific and technical community. It consists of scientific and engineering experts who hold responsible positions outside the government, and who are able to form independent judgements in a way the department itself cannot. ERAB is currently examining conservation R&D policy, solar R&D policy, and the role of the multiprogram national laboratories.

Snow also discussed the proposed reorganization, which would merge DOE into the Department of Commerce. DOE's research programs would hardly be affected. There would, however, be a new group of people to brief and convince. Since DOE came into existence in November 1977 nine different people have held the job of undersecretary, a position which includes managing DOE's R&D programs. A merger would cause another period of turmoil.

Other uncertainties arising from the budget process were also mentioned. The administration's proposed budget contains major changes which Congress will itself probably change. Many program managers have no idea what their final budget will be in FY 1983. Because of the numerous deferrals and rescissions some still do not know their final allocations for FY 1982. Under such conditions it is difficult to get substantive work done.

The national laboratories are another area of concern. University researchers have alternative forms of funding, but federal labs are funded only by the federal government. Consequently, reductions in federal funding translate directly to reductions in staff. Operating costs can only be reduced so much before people have to be fired. Those with low seniority, often women and minorities, go first, while those who can find

good jobs elsewhere, often the best people, leave. Snow said he hoped that one day managers would be able to make rational decisions instead of just reacting to bizarre situations.

Snow briefly discussed the problem of science and mathematics education. He pointed out that there are 16,000 school districts in the United States. Every scientist lives in one and has a local school board. A genuine grass roots effort in the scientific community will be necessary to change the current dismal situation. Even without large expenditures federal mission agencies such as DOE could help by providing leadership.

Basic research was another area discussed by Snow. Because truly fundamental research will not be supported by private interests, the administration has made a distinct effort to protect the basic sciences. The picture is not as rosy in some sub-fields, though. DOE's biological and environmental research program will be reduced from $210 million in FY 1982 to $170 million in FY 1983. This cut will have very severe impacts. People are generally unaware, he said, that DOE has supported some crucial, pathbreaking research in the biological sciences and that some of the national laboratories have unique capabilities to carry out certain types of research in biology and nuclear medicine. The scientific effort in these fields will be dealt a severe blow from these reductions.

Nuclear and high-energy physics share some special problems, namely enormous operating costs. In both areas there are prestigious committees of scientists from outside DOE providing advice on long-range programs. While DOE has followed their advice in high energy physics, the money is just not there for nuclear physics. Funding for nuclear physics is about level, which means that crucial facility needs will not be addressed. In the other areas that the Office of Energy Research is responsible for -- essentially all basic research at DOE -- there are at least cost-of-living increases provided in the budget. Nonetheless, facility operating expenses are very hard to keep under control.

Competition for funds can be very divisive, Snow warned. He reminded the audience that the national laboratories and the universities should have a symbiotic, not competitive, relationship. Scientists need to pull together to make the best use of available resources.

In response to questions Snow commented that previous DOE attempts to catalog specific national R&D needs were unsuccessful. Such needs are better determined by the

scientific community itself. Snow also guessed that the final appropriation for the biological and environmental research program would fall about halfway between the level the budget committee approved and what the President requested. The impact of the reduction will vary from laboratory to laboratory. Additionally, managers will be able to shift personnel from one project to another, although there are limits to how interchangable scientists are. Even relatively small program changes can sometimes cause major damage in an organization.

Snow responded to criticism of cancellations of cooperative programs with industry by admitting that the government had behaved inconsistently. This has been a problem internationally as well. Snow agreed that it's important that federally-funded research benefit U.S. private industry in the long run, although the payoff may be far off or unpredictable. He thought that a return to large demonstration facilities was unlikely, but that DOE will continue to try to pass along technical knowledge to private industry. Until DOE puts its own house in order, though, there will probably be no concerted program with respect to the private sector.

In answering another question Snow emphasized that the only high energy physics facility selection decision that had been made was not to proceed this year with the ISABELLE program at Brookhaven. The ring already constructed there may be used with some other machine. Snow said that he thought it unlikely that a decision to proceed with ISABELLE or any other new high energy physics facility will be reached in the next few budget cycles. He pointed out that the next big machine will probably operate from 1990 to 2010, so the physics it will produce will characterize the physics of the next century.

AGENCY PERSPECTIVES:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Moderator:
Peter B. Boyce *(Executive Officer, American Astronomical Society)*

Speaker:
Robert F. Allnutt *(Acting Associate Administrator, National Aeronautics and Space Administration)*

Agency Perspectives: National Aeronautics and Space Administration

Robert Allnutt, associate administrator of the National Aeronautics and Space Administration (NASA), began the session with a review of the recent history of NASA's budget. President Carter's budget for FY 1982 was $6.7 billion, which President Reagan reduced to $6.1 billion. The latter figure represented complete funding for the space shuttle, but 12 to 25 percent reductions elsewhere. Congress essentially went along with the Reagan proposals, but added a rider in the Omnibus Budget Reconciliation Act permitting the administration to reduce NASA funding by an additional 4 to 5 percent if it saw fit. In December OMB did so, cutting the areas which it planned to cut further in FY 1983.

The Congressional conference report had suggested that the reductions should be made in the shuttle program, but OMB made only minor reductions there. Instead it made major reductions in the areas of aeronautics, space applications, and space science. The specific casualties were civil aeronautics work, the Venus surface mapping project, the International Solar Polar Mission, and the Centaur high-energy upper stage for the shuttle. Among the survivors were the shuttle (albeit with a decreased flight rate); missions for the European-built Spacelab (also at a slower rate); the Gamma Ray Observatory (on a delayed schedule); the large Space Telescope; aeronautics research and technology development; and military systems work. There will be two new items for FY 1983: a mission to retrieve the Solar Maximum Satellite and repair it in orbit in 1984, and replacement of the steel solid rocket cases of the shuttle with lighter wound filament cases.

As the AAAS R&D Report shows, the FY 1983 budget will be $6.6 billion, which is an 11 percent increase over FY 1982 — healthy growth compared to other federal agencies. Most of this increase is for the shuttle, although there will be no funds for a fifth orbiter and the Centaur upper stage remains problematic. Apart from full funding for the Galileo mission

to Jupiter, there are no funds for free-flying spacecraft. Aeronautics research has been preserved, but development, such as work on fuel-efficient engines and composite materials, has been cut. NASA is hoping for some compromise from OMB here. Most of the increase in basic science will go to the Space Telescope, which is at an expensive phase of development, and to the Gamma Ray Observatory.

Allnutt said that he had never seen a year like this for NASA in Congress. The concurrent budget resolution contained the same figures for NASA as the President's proposed budget; however the House and Senate authorization committees made major changes. The House increased funds for mission operations and data analysis and for civil systems work. It directed NASA to revert from Centaur to the intertial upper stage and to continue study on communications satellites. The House also eliminated the Solar Maximum retrieval because, Allnutt believes, NASA overemphasized defense applications. The Senate, in contrast, approved the Solar Maximum retrieval, said yes to Centaur and no to the inertial stage, approved a fifth orbiter, and increased funds for aeronautics. The Senate's increases total $409 million, exactly what it calculates DOD underpays for the shuttle. (Allnutt's own calculation is about half of that.) The authorization bill as passed by the Senate thus contains these increases, cuts the shuttle budget by $409 million, and directs DOD to pay NASA an additional $409 million for use of the shuttle, some ten times what it now pays. Allnutt said he had no idea of how the House and Senate would reconcile their authorizations.

The appropriations committees have added to the confusion. The committees were not pleased with OMB's December alterations, and seized upon the Urgent Supplemental Bill as a way to rewrite NASA's FY 1982 spending plan. The report the conferees settled on has three major changes: $30 million is diverted from the shuttle to aeronautics, primarily to restore civil systems work; the inertial upper stage is terminated in favor of the Centaur; and the communications satellite demonstration project is approved. The report is consistent with the Senate and, except for the Centaur, House authorizations committees. Since the bill is likely to be vetoed for other reasons, NASA's budget for FY 1982 is still highly uncertain. Allnutt suspects that NASA may operate next year on a continuing resolution or a budget equivalent to the President's less some arbitrary percentage.

During the discussion there was considerable interest in multi-year funding. Allnutt said that although there has been some discussion of it with the relevant Congressional committees, there has never been any agreement, and it is no

longer under serious consideration. The reasons why multi-year funding is beneficial for DOD do not really apply to NASA. Additionally, even with multi-year funding, OMB and Congress could still reprogram and adjust NASA's budget. Instead, Allnutt said, NASA will try to promote better understanding of the need for continuity in many of its projects. The FY 1982 and FY 1983 budgets also suffered because NASA's chief administrator was not appointed until mid-August, just one month before the first NASA budget was due. The space telescope was particularly hurt by this. The Reagan Reagan Administration has begun the worthwhile practice of separating the shuttle from NASA's other activities, Allnutt noted. This enables the administration and the Congress to differentiate easily between major operating programs and other "controllable" expenses.

There has been some interest in getting the military to help pay for NASA. This year members of the House and Senate Armed Services Committees will take part in the House-Senate conference for the NASA budget. Unfortunately, while they are interested in what NASA does, they do not seem to be interested in paying for it. Defense R&D itself is having difficulty in Congress this year.

One question dealt with the problems NASA has encountered with the users of its data. NASA has suffered from the "we only put it up" syndrome, but has aired this problem quite well by now. Data analysis takes a lot of time and just isn't very glamorous. NASA is actively looking for solutions to this problem.

Allnutt then discussed the question of new starts. The Gamma Ray Observatory will be the first major new start in three years. Galileo will be the only major planetary probe of the 1980's. There are many good programs backed up, ready for detailed study, but there's a threat that funding for planetary exploration will dry up completely. This slowdown has serious effects in addition to the obvious ones, for when there are many new starts there are always funds available to help other programs. Without new starts, funding is far less flexible. Perhaps NASA should move to many small projects rather than a few large extravaganzas. The current short-term mission program, Explorer, has helped maintain continuity but has been cut back and is on a delayed schedule. On the other hand, Allnutt suggested, it is so expensive to send off a package that that one might as well put everything on it.

The final topic was international cooperation. NASA's attitude toward this is generally favorable, as is that of the Congress. International projects are difficult but are

cheaper for each country and involve valuable interactions among scientists with diverse backgrounds. NASA is talking seriously with the Europeans and the Japanese about a possible joint space station. It is also discussing such plans with DOD. The Europeans' experience with the International Solar Polar Mission has made them somewhat edgy about any agreements with the United States, however. They will probably seek a strong guarantee, which might be domestically difficult to arrange, or they might try to assume such an integral role in the project that we would not be able to back out.

AGENCY PERSPECTIVES: NATIONAL INSTITUTES OF HEALTH

Moderator:
Virginia Holt *(Office of Scientific Affairs, American Psychological Association)*

Speaker:
Thomas E. Malone *(Deputy Director, National Institutes of Health)*

Agency Perspectives: National Institutes of Health

Thomas Malone, deputy director of the National Institutes of Health (NIH), began with a review of the success of public support of biomedical research. NIH orchestrates a unique collaboration of government, universities, industry, and philanthropy to achieve an unparalleled research capability which has brought the U.S. past the borders of the biomedical revolution. Both the basic and applied research conducted by NIH have led to monumental achievements and unprecedented progress in molecular genetics, immunology, biochemistry, and biological technology and instrumentation. In Malone's opinion we have reached the most exciting moment of biomedical research and its applications to the improvement of the quality of life.

Nonetheless there is now a new imperative to reduce federal outlays. Fortunately, he said, the Reagan Administration recognizes the importance of biomedicine to the achievement of national goals and is dedicated to a strong national capability in research. Consequently NIH is doing well compared to other governmental programs. The main challenge will be to sustain research capabilities through a difficult period of economic restraint and political change.

At present NIH is operating under a continuing resolution passed on March 31 which will run to the end of FY 1982. Under this resolution the spending level for each institute is equal to the lesser of the FY 1982 House or Senate Appropriations Committee figure minus four percent. The final budget for FY 1982 will be about $3.6 billion. The President's budget for FY 1983 calls for a $108 million increase. Congress held hearings in February and March on the NIH budget but has taken no action since, in part because supplemental appropriations for FY 1982 have been more pressing. Committee mark-ups are expected in late July and August. In the concurrent budget resolution the Senate originally fixed the Health and Human Services (HHS) budget

at the FY 1982 levels plus $40.7 million for cancer research, while the House set it at FY 1982 levels plus $94 million for NIH. The final resolution settled on the FY 1982 levels for HHS plus $106 million for discretionary health programs, although it did not specify NIH. Malone hopes at least to see a genuine appropriations bill for NIH this year.

The President's FY 1983 budget for NIH contains a three percent increase over FY 1982. This does not keep up with inflation, so there will be more belt-tightening and painful decisions. The budget still places a very high priority on investigator-initiated research project grants. This year total of about 15,000 grant projects. This program represents about fifty percent of the NIH budget, as it has for the past several years. Grant expenditures will increase about 8 percent for new grants and 5 percent for continuations. The stabilization principle has not been abandoned, Malone said, but the goal of 5,000 new and competing grants just is not attainable given budget realities.

NIH is putting as much money as possible into research grants while still maintaining a reasonable distribution of funds in other areas such as contracts, centers, clinical research, and intramural research. While emphasizing basic research, NIH must also do applied research, and become involved in prevention. Because of the close relationship between the productivity of research and the renewal of the supply of researchers, NIH will support 9,000 research trainees in FY 1983. This is somewhat lower than in the last two years but is still within the range of the National Academy of Sciences recommendation. NIH will continue the present policy of providing approximately 50 percent of the institutional allowances payable in FY 1981 and will continue to pay 8 percent overhead.

Malone mentioned that the AAAS R&D Report described a FY 1983 increase in intramural research of 16.8 percent versus a 2.9 percent increase in extramural research. The intramural increase includes many mandatory increases, such as the federal pay increase. NIH is very concerned about this balance, but Malone wished to place it in a larger perspective. Over a six-year period research and training grants increased 67 percent while intramural research increased 79 percent. Investigator-initiated research, which is more similar to intramural research, is up 87 percent. The figures, he said, are clearly comparable.

A general ten percent reduction in reimbursement of overhead associated with research has been proposed for

FY 1983. Overhead reimbursement is important, but reductions have been made everywhere else. As yet this is still a proposal; there are other options, such as eliminating specific items or categories.

Prevention is also an important topic for Secretary Schweiker. There is a $589 million request for prevention-related research for FY 1983. This will be NIH's major concern; there will be minimal increases in other activities. NIH now has a special assistant to the director for research related to prevention. He will coordinate and highlight ongoing work.

Another priority at NIH is clinical trials. There are 700-800 ongoing long-term projects which are both very important and very expensive. Unfortunately, Malone said, the FY 1983 budget reduces support for them. For the first time NIH will need to decide which trials to support within the institutes.

Malone concluded by remarking that NIH has a heavy load in its FY 83 budget. It is trying to maintain stability in its research endeavor with a heavy concentration of investigator-initiated projects and an appropriate level of support for research training, both basic and clinical. NIH now has an agenda in prevention and health promotion. It will try to become more effective in bringing research findings to clinical trials and in applying them to health services. Within constraints the failing aspects of the biomedical apparatus must be strengthened, and funds must be allocated more efficiently.

One question concerned the erosion of NIH's special support in Congress. Malone agreed that NIH could once virtually bypass OMB. It grew almost forty percent each year from 1955 to 1965. Those days faded under the financial pressure of the Vietnam War, so that in 1970 NIH funding actually decreased by five percent. This was changed by the passage of the National Cancer Act, which rescued NIH but began an era during which special interest groups lobbied Congress for various specific programs. During this second period OMB developed into a financially conservative force. Malone believes a strong science advisory apparatus in the White House, such as George Keyworth is now providing, is needed to establish national biomedical policy.

Another questioner pointed out that the FY 1983 budget was actually $223 million below the FY 1982 baseline. Coupled with the reduction in new and competing research grants, in overhead reimbursement, and in research training

support, this represents a significant erosion in biomedical research support. Malone explained that there have been several FY 1982 budgets with which to compare the FY 1983 budget, but that the final FY 1982 budget used for baseline calculations is the actual budget as established by the continuing resolutions. He agreed that the last decade has seen practically no real growth at NIH, but noted that many areas of HHS had fared far worse than NIH in the last year. The apparatus now exists to watch out for excessive reductions, within economic constraints. NIH is trying to make the most efficient use of its available funds.

Malone also mentioned that NIH opposes the proposal in Congress to create a separate Institute for Arthritis and Musculoskeletal Diseases, for several reasons. NIH fears the diffusion of its diminishing funds. Furthermore, the arthritis programs are tightly interwoven with other programs, so that separating them out could damage both sets of programs. If NIH could be assured that all funding and staff needs would be met throughout the Institutes it would react more favorably.

NIH is very concerned about the small business set-aside, as well. At present NIH commits over $30 million to small business through competing contracts and peer review. Malone thinks this level of funding almost saturates the pool. Additional money specifically mandated for small business will clearly result in reductions in other areas of NIH. Malone hoped that NIH could be exempted from the set-aside or at least be allowed to use peer review in the process.

A questioner wondered whether there had been any discussion about elevating biomedicine from its current upper-middle priority level to the same high priority level as defense spending, as Dr. Press recommended earlier in the day. Malone remarked that while there was strong support for biomedicine there was no general effort to raise it to the same level as defense. Even so, the biomedical community has not done what it could to measure and publicize the economic returns of biomedicine. The virtual elimination of polio in this country probably saves $1 billion per year. More studies of the financial benefits of biomedical research are needed. Malone suggested that indexing, or some other method of stabilizing funding is called for, or biomedicine will be left to capricious forces, with accompanying wild fluctuations.

The final discussion topic concerned plans to involve industry in research traditionally supported by NIH. Malone said that last year grants were opened to scientists in

industry, under the same standards as others, though response has been light so far. NIH also now has industry members on its advisory committees. There is some hope that industry could provide more research support, but Malone doubted that there would be any general increase. Nonetheless, there may be some specific improvements, such as in drug development, and recent changes in patent law will probably increase industry research. The production of the Hepatitis B vaccine is a good model for cooperation among industry, universities, and government.

AGENCY PERSPECTIVES: NATIONAL SCIENCE FOUNDATION

Moderator:
Le-Nhung McLeland *(Department of Public Affairs, American Chemical Society)*

Speaker:
James M. McCullough *(Deputy Director, Office of Planning and Resources Management, National Science Foundation)*

Agency Perspectives: National Science Foundation

James M. McCullough, deputy director of the Office of Planning and Resources Management at NSF, opened the session with a review of the Foundation's activities. NSF makes over 12,000 awards each year, using some 40,000 reviewers in the process. Of the proposed $43 billion in federal R&D obligations for FY 1983, $5.8 billion is for basic research, of which $1.1 billion will be disbursed through NSF. NSF's budget is a particularly important part of federal R&D because it is often viewed as an indicator of the administration's approach to research.

There are several specific concerns that shaped NSF's budget this year. The Foundation is worried about both instrumentation and faculty shortages. It would like to expand the personnel resource base and improve industry-university interaction. Within its research support programs NSF tries to focus resources on areas of immediate concern rather than those which have already been explored, while considering the activities of other agencies, as well as national goals.

NSF is dealing with these concerns in somewhat indirect ways. Funds for instrumentation and facilities will be increased within the context of existing programs. The faculty shortage problem will be addressed by improving the climate at universities, primarily through the instrumentation program. NSF now supports 9,000 graduate students through its research projects, plus 1,390 graduate fellows. Despite the reductions in NSF's science education activities, the graduate fellowship program will not be cut. NSF will continue to fund cooperative projects and centers to encourage industry-university cooperation.

Program highlights in FY 1983 include: increases for computer research, including funds to broaden the base of universities which have capabilities for computer research;

added emphasis on mechanical, electrical, and computer engineering; emphasis on cellular and molecular biology; restoration of some funding for the social and behavioral sciences; more funds for geology; and transfer of the operation of the Antarctic ice-breaker to NSF from the Coast Guard. A decision is due soon as to whether NSF will operate the ocean drilling vessel "Glomar Explorer."

There are also some noteworthy small programs. There will be ten to twelve visiting professorships for women. There are new funds for minority research initiation, and a program for research improvement at historically minority institutions.

During the discussion, McCullough noted that NSF programs address national goals in a rather diffuse way. At one time there was a specific program of "Research Applied to National Needs," but it wasn't very productive. Now there is no special program, but, where possible, NSF gives preference to proposals which address national needs. Nonetheless, the Foundation looks first at scientific merit when considering proposals.

On the subject of interdisciplinary research, McCullough said there has traditionally been a problem in finding a home for such work and getting it reviewed properly. The new Office of Interdisciplinary Research, which is a small entity in the Engineering Directorate, will oversee major proposals to assure that they are properly reviewed and funded. Funding for interdisciplinary work often comes from several divisions.

NSF is slated to spend $6 million for university-industry cooperative projects. At the same time large amounts of money are being spent by industry in semiconductor and biotechnology research at universities. McCullough was asked whether NSF would try to further develop these two fields by funding university-industry cooperative research in them, or if NSF would try to stimulate new areas. He responded that NSF generally "goes with the flow" of its proposals. The original emphasis of the university-industry program was on engineering, but it has since broadened into chemistry, earth sciences, and physics. Interestingly, there are relatively few biotechnology proposals, apparently because researchers can obtain money elsewhere.

A questioner, noting that Congress seems likely to restore some funding for NSF's science education programs, wanted to know what NSF's priorities in this area would be. The highest priority would be teacher training, McCullough

said, particularly math and physical science teachers for high schools and junior high schools. NSF is concerned with both teaching skills and teachers' knowledge of their subjects. Nonetheless, Congress may well specify exactly how any restored money should be spent. In answering another question McCullough mentioned that there were very few funds left specifically for undergraduate institutions. There is a $2 million program to support research through instrumentation grants of about $20,000-$30,000 each, but nothing else.

McCullough agreed with a participant that historical precedent, not just proposal pressure, determines funding allocation. There is a strong tendency toward stability, which results in slow shifts at NSF. This is particularly true during times of budgetary constraint. One result of this is that engineering will continue to grow slowly, but will still not get as much money as engineers would like. Engineering does get substantial funding from other areas of the government.

McCullough explained that while instrumentation funds had increased about $1 million, there would probably be no line item in the NSF budget for instrumentation. NSF proposed such a line, to include major laboratory refurbishing as well, but it was eliminated in the Reagan Administration's FY 1982 budget revisions. It is still not clear whether it would be better to direct instrumentation programs centrally or along division lines, he said. NSF will try to convince OMB that it has reached the limit of improving instrumentation by increasing percentages within existing programs, and that more money and new programs are needed.

The final question concerned NSF's science education programs. McCullough explained that Congress restored only a very small amount of the funds which the administration had eliminated last year. Consequently the Science Education Directorate has been disbanded. Many of the staff members from this directorate now work for other parts of NSF, though, so a cadre remains if NSF should return to science education in the future. The director and the National Science Board have also established a commission to formulate an action agenda for science education. At the end of its eighteen month life it will produce a plan to involve parents, school boards, local governments, state governments, and possibly the federal government in improving science education.

BANQUET

Presiding:
D. Allan Bromley *(Chairman, AAAS Board of Directors; and Henry Ford II Professor of Physics, Yale University)*

Address:
Paul E. Tsongas *(Member, U.S. Senate)*

Banquet Address

Paul E. Tsongas

Research and Development: The Impact and Challenge

The U.S. economy is facing the greatest external challenge in its history. The challenge is being mounted by the Japanese. The issue is U.S. competitiveness in the world. There is reason for alarm, because the Japanese are beating the U.S. in many areas, and they are beating us badly. Especially on the frontiers of high technology, where the U.S. is the leader, the Japanese are challenging us as never before.

The issue is more fundamental than merely the trade imbalance, which is expected to reach $25 billion this year. Japan is moving its economy to the technological frontier. Having conquered televisions, radios, cameras, motorcycles, and automobiles, Japan has targeted high technology for its next onslaught. Already, Japanese companies have nailed down 70 percent of the world market in the newest generation of memory chips: the 64K RAM. The same companies now are aiming for the 256K RAM market and the next generation of "thinking" computers.

The Japanese capitalize on scientific research more effectively than we do even though much of that research is ours. Most importantly, they have used technology to increase their productivity dramatically.

The Japanese example is important not only because they are our chief competition in the world market, but also because they provide a yardstick to examine our own economic performance. One of the most important measures of economic health is productivity growth. What has been happening to U.S. productivity growth is distressing. From 1947 to 1967, U.S. productivity grew an average of 3.8 percent per year. From 1967 to 1977, productivity slumped to an average 1.4 percent increase. Since 1978, it has been marginally the same, if not waning. Waning productivity means less output per person, and therefore less to go around in this country.

The picture is much brighter in Japan. Japanese productivity has expanded at four times the U.S. rate since 1950. While Japanese output per worker is still only two-thirds the U.S. rate, they have been closing the gap swiftly. Japan is ending its fiscal year with a real growth rate of 2.7 percent, with unemployment a mere 2.1 percent. Compared to us, the Japanese are thundering along. And they have the momentum to continue.

The Japanese boom is occurring amidst an array of economic factors far different from our own. The savings rate in Japan, for example, is 20 percent of personal income, compared with a U.S. figure of about five percent. Thus, the Japanese have four times the leverage for capital investment, and four times the potential to accelerate their economic growth.

In Japan government and industry support for civilian research and development is a major priority. In 1978, Japan spent 1.9 percent of its GNP on civilian R&D while the U.S. spent 1.54 percent. While the Japanese are aiming for 3 percent by 1990, we are cutting our research funds. Japan, with half the U.S. population, matches us in the number of engineers graduating every year. Only one-sixth of U.S. secondary students take math beyond the 10th grade, while every college-bound student in Japan must study math and science every year of high school. Investment in U.S. high technology is left largely to private enterprise, with its orientation toward quick payoff on capital. In Japan such investment is nurtured by the government for the long term. These are only some of the many circumstances that distinguish the Japanese economy from our own.

Against this backdrop one fact stands in bold relief: the rate of U.S. technological progress has fallen behind that of our competitors. In short, U.S. technological leadership is being challenged. The answer is not trade reciprocity. Keeping Japanese products out of this country would be an opiate that would lull us into complacency while the real problems underlying our economy persist. The solution is not a drastic reduction in the role of government. The Japanese and the West Germans have far more interventionist governments than we have. Less government in certain areas may be appropriate, but wholesale abandonment of federal responsibilities would deny us critical tools and resources necessary to revitalize our economy.

There are six key areas in which we must take action if we are to avoid falling behind.

1. We need sharply higher U.S. investment in research and development. (I shall return to this subject.)

2. We must assure a supply of technically trained workers, scientists, and engineers by significantly upgrading our educational system. We cannot maintain a satisfactory pace of economic development and expansion unless we have the human resources to fuel that expansion.

3. We must encourage savings to generate more investment in American industry. We need the improved productivity that results from new technology embodied in new plant and equipment.

4. Labor and management must adopt a more cooperative, less confrontational spirit. Building motivation through shared ownership, participation in decision making, and other forms of cooperation can significantly raise productivity.

5. In settling disputes over regulation, business and government must negotiate more, innovate more, and litigate less.

6. We need policies that assure the availability of critical resources such as energy, water, and minerals. Increased efficiency of use and the development of substitutes should be priorities.

All of these steps help to increase the pace of technological innovation, which unquestionably contributes to increased productivity and economic growth. Further, in all of these areas, the federal government has a role to play. While it should be left to individual firms to integrate technology, capital, labor, and materials, the government has the practical responsibility of assuring an economic environment in which these resources are available and are efficiently used. We must therefore invest in R&D, in education, in resources that produce long-term benefits for the national economy as a whole. Individual businesses are unlikely to do enough.

The private sector has an excessive concern for short-run profits which often take priority over long-term investments. On the other hand, the public sector has a broader perspective but is inherently inefficient. The question is: how do we mix them so that government provides the longer view and the private sector provides the more productive environment? Ideology, either left or right, is not the answer. Saying, as the administration does, that education should be a state responsibility, and that technological innovation and increased productivity are the responsibility of industry, is shortsighted, and ignores reality. We must arrive at that combination of responsibility that assures action and efficiency.

As matters now stand the government does too little to foster investment in R&D. And at its own initiative the private sector under-invests in R&D. R&D is expensive, and is often risky from both a "will it work" and "will it sell" perspective. The rewards of R&D are often long-term and widespread. Given industry's skills at copying innovations and breakthroughs, it is often difficult for a company to obtain the full benefits of its research. In fact the social rate of return of R&D is generally twice the private rate of return. Market incentives do not provide an adequate level of R&D whether it be basic, applied, or process R&D.

At the same time, industry support of R&D should be favored. When motivated, industry can devote more resources more quickly and can more aggressively innovate and market new technology. The process by which government innovations are transferred into commercial products is difficult and not always done well. But that does not make government's role any less important.

The administration has taken an ideological approach to R&D. While not abandoning government support of R&D, it maintains that in order to bring economic recovery, federal R&D budgets must be curtailed. This is totally illogical. Instead of identifying the decline of R&D support during the past 15 years as one of the sources of economic weakness, the administration has proposed a 20 percent cut, when adjusted for inflation for non-defense R&D in FY 1983 compared to FY 1981.

The change in policy could have adverse ramifications. Abrupt changes in research funding break up research teams. Uncertainty over future funding diverts staff away from valuable work and into contingency planning. Shrinking budgets reduce opportunities for young investigators and tend to eliminate the riskiest and sometimes most exciting and

fruitful work. They sap the vitality of science by limiting inquiry. In the fields of energy conservation, space exploration, social and behavioral science, environmental protection, and science education, massive cuts disrupt whole domains of study.

The outlook is bleak. The AAAS R&D Report projects a 25 percent drop in support for non-defense R&D by 1987. The Report did not envision conquering cancer or solving our energy problems as a justification for these drastic cutbacks.

You can be assured that the administration is not eliminating basic research or plotting to send the National Science Foundation the way of the Department of Energy or the Department of Education. But the trend is disturbing. Stagnation is not an acceptable condition for the U.S. scientific enterprise. While the U.S. is still number one, our technological position is eroding and needs to be addressed now, not 5 years from now. The administration is moving in a direction contrary to the national interest. This view is shared by many of the administration's strongest supporters in the business community.

In addition to overall cutbacks, there are four aspects to the administration's approach that I find particularly troubling; increasing militarization of federal R&D, elimination of support for education, cutbacks in social sciences, and reliance on the private sector for technology development.

It is somewhat incredible to hear the Administration suggest that tight budgets are actually good for science and will improve quality. This approach somehow doesn't apply to the Defense Department. The administration budget leaves no doubt about the shift in R&D resources from civilian to military. While civilian basic research is stagnant, all areas of basic research in DOD receive increases. This trend is of particular concern, given the administration's attitude toward the national security implications of the exchange of scientific information. Military dominance of federal R&D will likely have a chilling effect on free inquiry and communication between scientists.

The administration's view that education is a state and local responsibility ignores the national importance of an educated citizenry and a supply of technically trained workers. It also belies the fact that the administration is significantly cutting aid to state and local governments. The emphasis on encouraging industry to participate in education at all levels is laudable, and should be supported. But it

should be recognized that investments in education are for the long-term. Only the most farsighted companies will devote significant resources, while most firms are putting off investments altogether.

Our entire educational system ought to serve career scientists, technical workers, and the public. There is evidence that it is not able to serve any of these groups. In our primary and secondary schools, math and science requirements are minimal and half of the teachers in these subjects are considered unqualified. In our universities, a glut of engineering undergrads is receiving less adequate training because of faculty shortages and obsolete scientific equipment. In our graduate schools, there is a shortage of scientists and engineers. Ironically, the immigration bill advancing in Congress would force foreign college students, who make up an increasing share of graduate enrollment, to return to their countries. This will further exacerbate the shortages of engineering manpower many firms are experiencing in critical disciplines such as electrical engineering.

The solutions to these problems are fairly obvious. We should strengthen industry-university ties and provide incentives for student and faculty support and equipment donations. But the balance of the support will have to be through federal support of graduate fellowships, college loans, instrumentation grants, and targeted grants to improve science and math education. The specific problems need to be sorted out, but federal leadership is essential.

The administration has assigned R&D in the social and behavioral sciences a very low priority. Yet there are some high priority questions that need answers. How can we best spur business investment? How should we lower interest rates? How can we reduce social spending while providing for the indigent? At the same time we must ask how to motivate workers, accelerate innovation, teach more effectively, improve the efficiency of government, and lengthen the time horizon of business.

Above all, we must grapple with the issue of overreliance on the private sector. Handing over technology development to the private sector without addressing the need to improve the rate and effectiveness of the innovation process is counterproductive. There is mounting concern that U.S. management is not an aggressive exploiter of advanced technology. Too often, small high-tech firms find Japanese companies more interested in licensing innovations than U.S. firms. There has also been criticism of U.S. management's overemphasis on short-term profits and underemphasis on the productivity and quality of the production process.

It is not possible to draw a sharp line between basic and applied research and technological development. We have to be flexible. Industry should be encouraged to do more through tax incentives, but if, for instance, an energy technology isn't developed or Japan beats us to the next generation of computers, the national interest is hurt.

While Japan has high quality production techniques and is now launching a new effort to expand basic research, the U.S. must maintain its strength in basic research and launch an effort in manufacturing technology. U.S. production process technology has not kept up with technological opportunity. Part of the problem is the generic nature of technologies such as automation, machining, chemical processing, and corrosion prevention, that are important to whole industries, but are too costly for any one company. To address this area, we should emphasize industry-wide joint R&D ventures. To facilitate this, anti-trust laws should be changed to exempt such joint ventures and federal financial incentives such as those proposed by the Carter Administration and those contained in the Stevenson-Wydler Innovation Act should be developed. Government assistance to help high-tech start-up firms should also be provided using the Massachusetts Technology Development Corporation as a model.

Many individuals have urged the science community to be realistic and help set priorities among research areas. I would urge you to be realistic and help set priorities for our nation's economic recovery. At the risk of sounding like a big spending liberal, I feel compelled to advocate more basic research, more applied research, more industrial research, more support for education, more incentives for innovation, and less ideology and untried economic theories. We need more experimentation in public policy approaches to innovation in order to find out what works best, and what combination of government, industry, and university resources maximizes the national interest. We need to work together and cooperate and not continue the polarization of government versus business.

Sputnik provided a visible symbol to rally the nation in the early 60's. The $25 billion trade deficit with Japan, the Japanese capture of 70 percent of the 64K RAM memory chip market etc., doesn't play as effectively, but is no less a call to arms. But it must be interpreted; the state of science must be presented to the public. Science 82 and other popular scientific magazines are a very positive step in bringing the excitement of scientific results and processes to the public in an understandable way.

The scientific community also needs to take the message to Congress as a whole and not just to the science committees

of the House and the Senate. While few members have staff assigned to science, many believe in the importance of R&D. The current budget process establishes priorities. It is a battle between special interests with clout. What's at stake is whether the budget has agricultural subsidies and pork barrel projects, or increased support for R&D and education.

There is also now a lively market for new ideas and approaches to productivity. The Democratic party is actively reformulating and there is a growing influence by younger members who recognize the priority of economic growth, and high-tech and R&D as the keys to such growth. Many Republicans also are looking at alternatives to the administration's approach. Scientists and engineers should seek more support among educators and industrialists. A national coalition could be established to call attention to the state of the U.S. scientific enterprise and to raise the importance of expanded R&D to our technological base.

It has been said that the politics of rebuilding our economy with increased support for R&D, education, investment, and labor-management cooperation, won't sell. It doesn't excite. We have a serious problem when what works won't sell and what sells won't work. It's a challenge we share. It's a challenge we can't ignore. Too much is at stake.

R&D IN THE FY 1983 BUDGET: IMPACTS ON INSTITUTIONS

Moderator:
Gail Pesyna *(Member, AAAS Committee on Science, Engineering and Public Policy; and Program Specialist, New Business Programs, E.I. du Pont de Nemours & Co.)*

Speakers:
David V. Ragone *(President, Case Western Reserve University)*

Martin Goland *(President, Southwest Research Institute)*

David Shirley *(Director, Lawrence Berkeley Laboratory)*

R&D in the FY 1983 Budget: Impacts on Institutions

Introduction

Gail Pesyna

The topic of this session, as you know, is "Impacts on Institutions." In itself, I think this is a challenging assignment for our speakers since we are asking them to predict the future, if you will, in a period of high uncertainty and turbulence.

In one brief period of my life before du Pont I worked, one might say, as a bonafide futurist. You quickly learned in that business that there are two major schools of thought: one is that the future is going to be more or less like the past; and the other school of thought is that the period of crisis and change that we're in at the moment signifies a period of discontinuity, and a future that will be very different from the future that we might have expected in the past. The latter of these is viewed by most bonafide futurists as being intellectually the most interesting because it allows for flights of imagination and creative thought. But in fact we tend, as individuals and organizations, to run our lives and our institutions based more or less on the former set of assumptions: that the future is going to be pretty much like the past.

So we find that when we're faced with change it is generally unwelcome and it can be very disruptive. In fact, it tends to undermine our confidence in our ability to predict the future, and in the case of the session this morning, in our ability to predict the impacts on our institutions of a changed R&D policy in the federal government.

Combined with this is an additional challenge to our speakers, and that is that there is probably no time when we

are more sensitive to our interdependence as institutions, our function as a research system, than when we are in a period of change or crisis. We find that we're not really dealing anymore with inanimate organizational charts. Rather we're dealing with a dynamic living organism, if you will, composed of human beings who have a natural tendency to want to grow. We also find that the impacts on one part of the organism affect the choices and the plans and the expectations of the rest of the parts of the system. And so the complexity of these relationships also makes it more difficult to predict the future or the impacts on any individual institution. But that is what we are asking our speakers to do this morning and I'm sure they will rise to the occasion.

As I reflect on the mood of the country and of this community in general this morning, I'm reminded of a Peanuts cartoon I read a few years ago, and if I can recall it it goes something like this: Lucy has suffered a major setback at school and she's walking home and she's grumbling along the way about "Why is life such a series of ups and downs? No sooner do you experience a magnificent up and somebody deals you a down. Up and down. Up and down." She reflects on this with a stodgy silence for a minute and then says in a very loud and frustrated voice, "Why can't my life be all ups?" And I think that perhaps in this period of time as we view the economy and in fact the prospects for R&D in the federal budget, many of us wish the same thing: Why can't it be all "ups?"

David V. Ragone

I have been asked this morning to comment on the impact of the federal 1983 research and development budget on universities. Before I begin, let me acknowledge that my task was certainly made easier by the fine compilation of information in the seventh AAAS Report on research and development. My thanks to the authors for preparing as good a summary of a confused situation as I have seen.

To turn to my subject, it will come as no news to you that there has been an anguished outcry from universities in response to FY 1983 budget discussions. The intensity of the outcry seems to be out of proportion to the magnitude of the problem, if the problem is defined simply by the amount of money budgeted for university R&D over the last few years and the amount projected for 1983. Anyone who has had the responsibility for allocation of funds instinctively measures two characteristics of the sounds coming at him during the process -- the volume and the average tone or frequency. The sounds I hear lately have been louder and more shrill than I would have expected if I had been looking simply at the numbers in Table 4-2 and 4-3 of the AAAS Report.

From Table 4-2 I learn that the money available from all sources for R&D in universities has (in constant 1972 dollars) grown from about $2.6 billion in 1967 to about $3.1 billion in 1981, then declined to about $3.0 billion in 1982 and will probably drop a bit in 1983. From Table 4-3 I find that there is a projected increase of 5.2 percent in federal support of university research between FY 1981 and FY 1983 in current dollars. True, this increase in current dollars is really a decrease of almost 10 percent in constant dollars, but this reduction is not as serious as the cutbacks in other programs supported by the federal government nor as serious as the declines suffered by many of the nation's business organizations. In comparative terms, we certainly can't complain about the treatment basic research has received. Yet I hear an outcry and many expressed feelings of despair.

Nobody welcomes a budget cut, but in times of national financial stress it seems almost unpatriotic not to ask what one can contribute or not to respond when asked to set

priorities and make choices, recognizing that not all of the research being supported is of equal quality and importance. Those who participate in the outcry are surely not unpatriotic nor are they unthinking men and women. There must be some answer.

I believe the reason for these feelings of dissatisfaction lies in the context in which some of these cuts are being taken -- the level of support when measured against the perceived job to be done; not the incremental increases or decreases from one year to the next. It also has to do with the style of budget management -- the way things are done, or at least the perception of way things are done, from the viewpoint of the university.

Universities are intended to serve the long-term benefit of society. From universities should come not only knowledge gained through research and scholarly activities, but also graduates who will carry on that research in the future. The message coming through to us in universities these days is that we need more of both: more knowledge to enable us to compete more effectively in international trade and to understand social and economic phenomena: and more people prepared in science and technology, prepared better than they have been in the past. The two are, of course, related because research activities are an essential part of the educational scene in science and technology.

To run a successful and responsive university requires, in addition to financial solvency, a vigorous faculty, and an adequate supply of interested and able students.

A vigorous and vital faculty requires a constant infusion of young, active minds not only as the source of the senior faculty members of the future but also to keep the place stirred up. It's easy to underestimate the importance of stirring things up once you've become part of an organization. For example, during my first year at Case Western Reserve University, applications for undergraduate admission were up about 20 percent, and the entering class was up 17 percent. One of my colleagues was describing the events he thought might account for that outcome, and near the top of his list was the fact that the university had just hired a new president. As he worked his way through the rest of his list, I began preparing a modest set of remarks in which I would share the credit for this good fortune with the faculty and staff who had worked so hard -- but I was understandably flattered by his observation. Before I had a chance to speak, however, he began to review his list of things the university ought to do to ensure a similar increase in enrollment for the

following year. At the top of his list was "get another new president." To repeat, it's easy to underestimate the value of stirring things up.

Some of the discouragement in universities these days is based on our inability to attract and retain good young faculty members in science and technology. What motivates young people to join a faculty? Certainly it is not financial gain. Primarily they are motivated by the desire to pursue a subject of interest in great depth, to teach, and in general to progress professionally. Professional progress in the sciences and engineering requires financial support and access to modern research facilities. In a period of shrinking support younger faculty members will have a more difficult time competing for grants against better established investigators. And the research facilities of universities are becoming increasingly less attractive as compared to similar facilities in the industrial world. This is especially true in those areas of engineering and technology related to design and manufacturing, and therefore to the major determinants of productivity. Unfortunately, the projected FY 1983 budget doesn't hold out much hope in these two areas.

But perhaps we should not focus the blame for these shortcomings solely on the federal R&D budget. Perhaps we in the science community should redraw our priorities to devote a greater proportion of our funds to equipment and to grants for young investigators. But even if we do, we still need something else to create an attractive environment for new faculty and that is an atmosphere of confidence, confidence that with high probability there will be continuing support for good work. While I know that we can't totally escape from uncertainty, I would say that this year's budgeting process was certainly not designed to create confidence in the ongoing support of science.

The other ingredient needed for doing our job is a supply of interested and able students. As we try to respond to what we perceive to be an increasing demand for graduates skilled in science and technology we have two factors working against us -- the shrinking total pool of students and the decreasing fraction of that pool with talents and interest in quantitative matters. On the first factor, it is clear from population statistics that the size of the 18-to-24-year-old cohort will decline by over 20 percent in the next fifteen years. We can't do much about that. But we might be able to influence the second factor, the mathematical aptitudes of those students who apply to universities, especially those at the higher end of the scale -- those who are much more likely

to make significant scientific contributions. Unfortunately, the trend is in the wrong direction. A look at the SAT scores in math will illustrate my point. In 1977 about 9,000 students nationally scored over 750 out of a possible 800 on the math SAT exam. In 1981 about 6,600 did, down about 25 percent. At the same time those scoring between 550 and 599 changed little, from about 118,000 to 114,500. I can't believe that this phenomenon is due to a biological or neurological change in 18-year-olds. I believe that this confirms what many of us in universities have suspected for a long time, that the level of teaching in science and mathematics at the secondary level is declining. Needless to say, this will have a long-term impact on research universities and on research. It is for that reason that I register serious concern about decreased federal interest in and support of science education, which should be a national issue.

Now all of the foregoing may sound like an argument for the status quo, for steadily increasing federal largesse for basic research and science education. I didn't intend it to be, primarily because it is unrealistic to expect such increases in the face of large overall deficits. But I think we can call for understanding and an appreciation of the complexity and vulnerability of the research system existing in the universities of our country, a system that Frank Press describes as an intricate tapestry of graduate education and research.

The system involves facilities provided from private grants, as well as from public funds; it involves faculty for whom research forms the basis of continued high level teaching and who derive their support through tuition, through private grants, through contract research and through consulting; it involves students, many of whom are supported by grants and loans; it involves industries who sponsor work for their ultimate gains, and it involves the federal government which supports and monitors virtually all aspects of the system for the benefit of the public. And it has been an enormously successful system, I believe. It is not a formal system of neatly defined relationships based on contracts. It is an informal system based on a set of customs, practices and informal treaties. It is a productive system when it's running well, but its stability and productivity depend on confidence and that in turn depends on the behavior of the participants. Even with shrinking budgets, the integrity of the system can be maintained if the participants recognize the fragility of the tapestry and act accordingly. Specifically, it is destructive of the system for the federal sponsors to view themselves simply as purchasers of research and not as participants.

I am reminded of a comment made by one of my predecessors at Case Western Reserve University who stated that as president he soon learned that the right way of doing things is often more important than the right things to do -- and he learned that colleges are run on a subtle and volatile thing called morale and not on formal authority.

I refer to the qualitative aspects of the system because some of the impact of the FY 1983 budget process on universities is qualitative as well as quantitative. The process itself will influence us as much as the product because the process has generated a great deal of uncertainty. Chapter six of the AAAS Report points out that the budgetary process is never tidy. That is true. But the last few years have seen an amplification of the fluctuations and thrashing about that has been unnecessarily untidy and demoralizing. An example is the threatened reduction by NIH of indirect cost recovery payments by an arbitrary ten percent, which strikes me as an abrogation of a long-standing treaty -- albeit an informal treaty. And that certainly will not build confidence among the other participants in the process.

The lack of closure in the FY 1983 budget also shakes the system. Universities must make hard salary commitments to faculty members by June. But part of the income to pay these salaries will come from federal R&D budgets that have not yet been established. The risk is increased. Once the academic term starts in September, most universities will, by established practice, be committed to support faculty members, even untenured ones, for the year beyond the 1982-83 academic year, at even greater risk. Universities will necessarily become more wary of these long-term commitments -- to the detriment of the research enterprise which needs a certain adventuresome spirit to flourish.

What are the alternatives? No doubt universities will reach for other sources of support. Private grants from foundations and individuals have always been available and eagerly sought. They will be pursued even more vigorously, I'm sure.

Research-based universities will also turn more seriously to the industrial world for support, and this is not necessarily bad. We as a nation seem to be having some problems with technology transfer. It will probably help to have the transferrer and the transferee both in on the basic research. And there is another advantage to industrial sponsorship -- that of greater stability. By and large, the managers of industrial research efforts understand that in research, especially basic research, there is nothing

fundamental about the time it takes the earth to make one trip around the sun. Thus there is a good deal to be said for asking the private, industrial sector to support more of the cost of university research, and we should.

But we can't expect industry to take up all the slack. The level of industrial support is less than 6 percent of the level of federal support of university research. To compensate for a 6 percent cut in federal support would require a doubling of industrial support. Some increase in industrial support would be welcome, but I am concerned that if we turn too strenuously to the private sector we stand a chance of altering the nature of the research that will be done because we will substitute private sector values for public sector values. That is not intended to denigrate either set of values but simply to observe that the two are different.

We expect the federal government to enhance the public good in the long-term -- to serve as advocate for the same social compact that has granted a special role to universities. The private sector, even though it can have a long-range view, must nevertheless act to preserve and enhance its own financial integrity in the long run. In some cases there will be a coincidence of interests between universities' research desires and the activities and the needs of industry. But that will not always be the case. Our colleagues in the newer areas of biology are trying to thread their way through some of these issues and find that it's not easy going.

To conclude, let me note that, as I have indicated, a shortage of money is not the only or perhaps even the main problem with the FY 1983 research budget. The corollary, of course, is that the solution to the problem is not simply to add money. Yet I cannot leave you without noting that academic research is being turned to for important contributions to such national priorities as:

- economic development,
- industrial employment,
- international technological competitiveness,
- military preparedness, and
- improved health.

The list could go on, but I think my point is made: the nation is counting on us to produce, and we're going to do our

best. But there is a great deal of pressure on us. We'll need the cooperation, understanding and full participation of the federal government in order to succeed. I don't suggest that federal agencies suddenly abandon cost-controls, but rather that it once again become fashionable to rely on mutual trust and good will among partners who are passionately devoted to the same purposes.

To quote again from my predecessor, President Wickenden:

> "Idealism without efficiency is futile;
> Efficiency without idealism is fatal."

Martin Goland

Near-Term Program Outlook for the Independent, Not-for-Profit Applied Research Institutes

What I've been asked to do today is to discuss the FY 1983 prospects for the community of "not-for-profit" institutions. I've chosen, quite arbitrarily, to concentrate on a subgroup of eight such organizations which are commonly referred to within the R&D community as the independent not-for-profit applied research institutes, and I emphasize the word "applied."

The number of not-for-profit institutions in our country conducting research in a wide variety of areas is of course very large. Even if we restrict our sights to those engaged primarily in science and technology the list is extensive; more than 40 independent not-for-profits have exclusive interest in the area of basic biomedical research.

One of the things that has surprised me is that there has not been more discussion at this meeting of the difficulties being faced by the community of biomedical research institutes and in fact by the community of medical schools and departments of biology throughout the country. Associated with our organization is one such institution, the Southwest Foundation for Research and Education, and until recently I was president of that organization as well, so I have some familiarity with the situation being faced in terms of research support in that area.

To a very large extent, the fate of biomedical research support nationally follows the fortunes of the National Institutes of Health, and to a lesser extent the National Science Foundation and other federal agencies. The past decade has seen a history of gradually reducing support; although the actual dollars have risen slightly with each new budget, the magnitude has been well below the annual rate of inflation. The impact on the overall effort has become more severe each year and has now become serious. For FY 1983 the current plan is to reduce the number of competitive grants awarded by around 20 percent, and this is to be accompanied by

an across-the-board reduction in allowable overhead rate on all NIH grants. If the latter restriction is not implemented (and it is being strongly resisted by all grantee institutions), the number of competitive grants will be reduced further.

I did not come prepared to discuss this issue in detail, but I can tell you from personal observation that one of the results of the intensely competitive climate for competitive grants is that promising younger scientists are being driven from their intended careers in medical and biological research. Younger scientists suffer most in such a climate, and when they see the opportunity to become principal investigators dwindling, they look elsewhere for career opportunities. Based on my own observation, the impact of budget restrictions in the biomedical area is far more severe than in the physical science and engineering research areas. This is particularly unfortunate at a time when the horizons of biology and medicine are expanding almost explosively, with great promise for new and beneficial findings.

Other organizations which fall into the not-for-profit category are RAND, Mitre, Aerospace Corporation, Draper Laboratories, and so forth. I have chosen not to address them in this talk since they were all organized to meet specialized government research needs; even today their programs are still essentially, if not entirely, government funded. The earlier discussion of FY 1983 government funding plans relate directly to the prospects faced by these institutions.

Let me now return to the principal theme of my talk, namely, the prospects in FY 1983 of the group of eight independent not-for-profit applied research institutes.

My reason for concentrating on this group is, first, because this is where I am most intimately involved professionally, and second, because these institutions are unique in their charter obligations to serve both industry and government in applied research. In the development of this group, service to industry was considered the primary objective.

Each year these organizations conduct thousands of applied R&D projects for a very large number of private companies in all size categories. In addition, they serve most of the federal agencies and many state and local governments as well. Because of this characteristic of our operations, an account of how we view the near term -- and by that I mean FY 1983 -- for applied research and development

seems appropriate. Let me hasten to add that I'm speaking as an unofficial representative of the not-for-profit group, and any opinions advanced must be taken as strictly my own. In the preparation of these remarks I have, however, had the benefit of inputs from the heads of the other institutions.

Before looking to the probable FY 1983 scenario, I shall take the liberty of briefly describing who we are, how we came into being, and what we do. The members of the group include Battelle Memorial Institute, Franklin Institute Research Laboratories, IIT Research Institute, Midwest Research Institute, Research Triangle Institute, Southern Research Institute, SRI International and Southwest Research Institute. The impetus for the founding of these organizations came from private citizens in various parts of the country, who in the years directly following World War II established them as intended centers of excellence, aimed primarily at strengthening scientific and technological capabilities, with the original intent of supporting the economic development of their regions.

Very quickly, the geographic and regional aspects of the programs of these organizations pretty well vanished and their outlook for various reasons became national and, increasingly, international. Within each organization will be found a program breadth which embraces the various branches of engineering, as well as the physical, chemical and biological sciences. Most of the group also include in their coverage economics and social sciences and management science as well.

The cumulative gross revenues of these eight institutions in FY 1981 was in excess of $720 million; total permanent staff is around 14,500, of which 6,500 are in the professional category.

Since FY 1981 national expenditures for R&D totalled approximately $69 billion, the not-for-profits accounted for only around 1 percent of the national effort on a dollar basis. While 1 percent does not seem to be a very large number, I believe I am justified in saying that the impact of these organizations on the national scene is considerably greater than the dollar-measure implies. The most convincing proof for this is the magnitude of the client lists to which I have already referred. At one time or another, and in many instances on a continuing basis, almost every company or government agency involved in applied R&D in the U.S., and many abroad, have seen fit to employ the services of these organizations. The not-for-profits have few of the problems which tend to hamper industry-university collaboration

because by their very nature they guarantee the security of proprietary information, as well as the patent rights of clients. It is to our credit that over the years, to the best of my knowledge, this trust has never been violated by any of the group.

The FY 1982 Experience

Before looking at probable trends for FY 1983, it is worthwhile reviewing briefly what has happened thus far in FY 1982. The prediction for gross revenues for the group in the current fiscal year is around $750 million, compared with $722 million in FY 1981. This is a 4 percent increase, as compared with 8 percent for FY 1980-81, and even larger growth in the years before that. Based on the information supplied me by the other institutional heads, the reduction in rate of program growth is due to readjustments in project volume on the government side and is a reflection of changing R&D policies and priorities of the various federal government agencies.

The major influences during FY 1981 were the indecisions caused by delays in arriving at final agency budgets, a reduction in emphasis on R&D relating to environmental-and regulatory-related matters, and the beginnings of a shift from support of "soft" sciences to greater concentration on the "hard" sciences and engineering.

It had been anticipated at the start of the year that new DOD initiatives would account for significant increases in funding. While some project acceleration has begun to appear, the overall effect in FY 1982 appears to be disappointing. On the other hand, DOE, EPA and DOT funding has shown definite decreases. Since the not-for-profits are not strong participants in the NSF programs, little effect from that source is evident.

Industrial volume has been relatively unaffected thus far, even in the face of the current recessionary environment. This applies both to dollar-volume and to program content, the latter being heavily weighted with product- and process-oriented projects with relatively near-term payoffs.

It should be noted, of course, that FY 1982 must be viewed as a year of transition in the sense that the Reagan Administration policies have not yet made their full impact. For better or for worse, what takes place in FY 1983 will be

a better indicator of the new directions of national R&D policy.

Looking Ahead

The crystal ball for FY 1983 is a clouded one for two principal reasons. First, although the intent of the administration in regard to science and technology has been made clear in the initial budget presentation, the conflict of views with, and within, the Congress promises no early resolution. Once again, therefore, we may be faced with a period of indecision until well into the fiscal year. In the industrial sector, a key factor will be how soon the current recession gives way to economic recovery.

It should also be pointed out that forecasting future program levels for a group of institutions whose total revenues are but a fraction of the national effort is made doubly difficult because the link between their level of activity and national trends is at best highly diffuse. It is clear that in FY 1983 government support for policy studies, economics research and social science will be severely reduced, and those institutes heavily involved in servicing such areas will be severely hurt. On the other hand, in the so-called areas of "hard" science and engineering the overall level of activity will be roughly maintained, and the success of the individual not-for-profit in the marketplace will depend primarily on the excellence and creativity of its staff, and the ability to flexibly alter its marketing goals to correspond with changes in the pattern of client needs. In fact, one of the characteristics of these applied organizations is the rapidity and flexibility with which they can shift their programs to correspond with market needs. I make no apology for that. In many cases we have pioneered new technical directions. But our goal is not primarily the pioneering goal of basic research. It is the applied research mission, in which it is essential that you be able to shift program direction to meet the needs of your clients.

Looking ahead first to the government side, in the non-defense areas there will be a continuation of the trend toward shifting responsibility for near-term research to industry, along with an effort to concentrate government-funded R&D in longer-range, high-risk areas. Even so, resources will be limited and the intention is to emphasize "winners" with a high potential pay-off. Unless considerable discretion is used in carrying out such a

policy, there may be problems. I am reminded of the classic answer given by department store magnate John Wanamaker when he was told that at least half of his store's advertising budget was wasted. His reply was that this was entirely obvious to him -- his problem was that he didn't know which half.

Should the industrial community respond to the need for increased R&D activity, the not-for-profits are ideally suited to benefit since their policies and methods of operation are tailored to meet the needs of industrial clients with regard to schedule and cost deadlines, and proprietary protection.

In other areas of government R&D, the not-for-profits have been among those active in conducting research needed to support sound regulatory policies, serving such agencies as EPA, NIEHS, DOE, OSHA and DOT. The intention of the administration is to reduce the degree of activity in such areas, a process which began in FY 1982. In some instances, diminished activity is reasonable; for example, cutbacks in funding aimed at developing assay procedures for air and water quality are justified by our now having available valid analytical procedures to accomplish most of the necessary objectives. On the other hand, the interpretation of pollutant levels from the public health standpoint continues to be in need of aggressive research which is not being implemented. Emphasis on hazardous waste issues is being increased, a positive action, but the National Toxicology Program is being directed toward the use of scientific "shortcuts" of questionable efficacy.

Regulatory-related R&D spreads across many fields of science and engineering, of course, and it is not possible to discuss each in detail here, but as a general conclusion it appears that in FY 1983 the not-for-profits will suffer some further program reductions. In certain more fortunate areas, a reorientation toward meeting industrial needs will be possible, but usually at the expense of concentrating less on more fundamental issues and more on shorter-term objectives.

In the energy area, the story is much the same. Insofar as broad policy is concerned, one cannot quarrel with decisions to terminate engineering and demonstration programs which are of marginal value in promoting marketplace utilization, and to concentrate government support in longer-range, high-risk research. Yet, it is difficult to endorse a program which permits the U.S. state-of-the-art in advanced commercial nuclear fission reactors to fall even

farther behind those of other nations, and which in many areas transfers to industry responsibilities which realistically cannot be expected to be met. The shallowness of our national energy planning, for which the government cannot evade responsibility, is well exemplified by the sudden starts and stops in advanced energy R&D which accompany short-term fluctuations in petroleum crude prices.

The bright spot anticipated in FY 1983 R&D funding by the government is, of course, the Department of Defense. I have already remarked that the increase in DOD activity expected during FY 1982 has not yet materialized, but it seems clear that the coming year will see an upturn. The paradoxical government policy often pursued will again be at work, namely, an increased level of agency R&D responsibility and funding, coupled with a continued reduction in in-house personnel spaces. This forces increased R&D dependence on outside contractors, including the not-for-profits.

In fact, based on my survey of the group, the expectation is that total government support for FY 1983 will remain at about the same level as in FY 1982. Considering that there will be some reductions in non-defense R&D areas, the counter-balancing equalizer is expected to come from DOD activity. Moreover, with the increased emphasis on basic research in military-related fields, this will probably strengthen not-for-profit programming along these lines, a most positive development from our point of view.

The Industrial Scene

The pace of the not-for-profits' industrial activity during FY 1983 will, as already noted, be dependent on the national economic climate. An upturn in industrial profitability, coupled with more reasonable interest rates, will be the ideal setting for industry to expand its R&D horizons to combat the growing competitive thrust of Japan and other high-technology nations.

Granted the important role of R&D in maintaining industrial leadership, it must also be emphasized that the restoration of U.S. preeminence depends on a symbiotic relationship between technical innovation and excellence, and many other important factors as well. A recent paper by Jordan D. Lewis ("Technology, Enterprise and American Economic Growth," Science, vol. 215, 5 March 1982) is in my view a splendid discussion of our future national imperatives. At the risk of over-simplification of the

issues, may I point out that our economic viability will depend increasingly on the vigor of our high-technology industries, and for these to prosper, changes in many of our attitudes toward education, management and investment policies, and industry-government relations will be required. For example, I note with some amazement, as quoted from the New York Times, that a few members of the Harvard Business School staff have now decided that industry leaders should really know something about, and have an emotional involvement with, the enterprises they are managing!

Based on our experience, and I believe that of others, it appears that U.S. industrial R&D has concentrated largely on near-term benefits. For the sake of balance may I point out the excellent session we had yesterday afternoon is not representative of U.S. industrial R&D attitudes. Those companies we heard from were a very small number of very progressive, very high technology-oriented companies. These do not reflect in fair measure the much closer end view which American industry on the average has always taken in R&D. Whether or not this is going to change, we shall see. There is evidence of change along these lines, but it will be slow to develop, and will require attendant changes in government attitudes which may be even slower in coming.

For FY 1983, when the main effort will be to restore corporate profitability, the complexion of our industrial programs will probably see little change. With economic progress, however, it should be a reasonable growth year for the not-for-profits, especially in the "hard" areas of science and engineering. If profitability is restored then perhaps matters will ease up and a longer-range view for industrial R&D will come into focus.

Conclusions

Program emphasis in the government sector will shift toward defense R&D, and industrial activity could well increase if there is an improvement in the general economic climate. These conditions are for the average, of course, and individual not-for-profits will fare better or worse depending on their program orientation, the skill with which they meet various markets, and on the creativity and excellence of their staffs. Those with heavy "hard" science and engineering capabilities will probably have the least difficulty and find the greatest opportunity. In summary, let me say that as far as our institutions are concerned, FY 1983 will not be a bad year, it will be a good year, with some growth. At the most pessimistic forecast level, gross revenues could remain similar to those of FY 1982.

David Shirley

This talk will have two major objectives. First, as director of a Department of Energy national laboratory I shall present a factual report on the impact upon our laboratory of the policy changes and budget actions in Department of Energy programs since early 1981. Second, I shall offer some personal views on more general problems that appear to underlie the immediate topic of this year's symposium: namely, the interaction between the federal government, which supports research, and the scientific community, which performs it.

A major share of the research and development program conducted by the Department of Energy is carried out in its national laboratories, which are government-owned contractor-operated (GOCO) facilities. The multiprogram national laboratories form a subset of these. Each laboratory has its own role and "personality". We are therefore dealing with a very complex issue discussing the prospects for the laboratories in the FY 1983 federal budget. Nevertheless, some generalizations can be made.

To start with an overview, we can look at Table 4-4 from this year's AAAS Report VII. From this table we note that the 12 multiprogram laboratories show an average decrease of 20 percent in their budgets in constant dollars from FY 1981 to FY 1983. The magnitude of the cut varies substantially from laboratory to laboratory. This is a consequence of their being multiprogram in nature, and therefore being affected differently by the selective philosophy of federal program support of R&D by the Reagan Administration. In general, defense programs and nuclear energy programs are being increased. There is a small dollar increase in support of basic energy research, with a concomitant small reduction in real support. The energy technology programs (conservation, solar, geothermal, fossil energy, and energy storage) are experiencing substantial budget cuts.

Changes of budgetary emphasis are, of course, entirely within the prerogatives of the administration, as part of the political process. It is very unusual for the R&D programs at multiprogram laboratories to be so close to the political firing line as to wreak such hardship on the laboratories, but

the transition from the Carter to the Reagan Administration was unique in many respects. If these budget figures were the final values, the effect on the laboratories would be painful but definitive. The laboratories exist to conduct R&D to fill national needs. They would adjust to carry out their newly-defined missions.

No discussion of the FY 1983 budget would be complete, however, without noting that the figures given above would follow from the budget proposed by the administration. The Congress has a somewhat different perspective, particularly on the energy technology programs. They are prone to augment the budget substantially in these areas, albeit not to anywhere near the levels of FY 1981 and before. A major problem faced by the laboratories in late June is the lack of any really accurate projection of the size and distribution among programs of their actual budgets for FY 1983, which starts October 1. Because the size and composition of the work force which will be required to carry out the DOE programs in FY 1983 is still unknown, the laboratories are unable to plan or act really effectively.

This uncertainty was the subject of a recent hearing of the House Science and Technology Committee on June 2, 1982. Representatives of four multiprogram national laboratories, including ours, testified about the required reduction in force of laboratory employees, based on the administration budget and on the continuing resolution. Inasmuch as these figures are part of the public record, I have set them out in Table 1. Because of the fluidity of the budget situation, these figures have only transient value. The real situation is worse than the numbers alone would imply because different employees would be affected by the two outcomes, reflecting the administration-congressional schism in DOE programs.

The above comments apply to multiprogram laboratories generally. We conclude that the laboratories are heterogeneous, that their R&D programs are being reduced substantially on the average, and that we are in a period of tremendous budget uncertainty. I'd like now to focus on one particular laboratory -- the Lawrence Berkeley Laboratory.

Lawrence Berkeley Laboratory is a multiprogram national laboratory situated in the Berkeley hills contiguous to the campus of the University of California, Berkeley. It is unique among the national laboratories in that approximately half of its senior scientific staff are faculty of U.C. Berkeley. With 600 resident graduate students, Lawrence Berkeley Laboratory is the largest single provider of scientific and technical Ph.D. talent trained in energy

TABLE 1. Reductions in Force at Four Multiprogram National Laboratories Required by FY 1983 DOE Budget

Laboratory	President's Budget Case	Continuing Resolution Case
Brookhaven	250	450
Lawrence Berkeley	500	200
Los Alamos	370	500
Oak Ridge	400*	200

* "Most likely" case, not President's Budget case.

Source: House Science and Technology Committee Hearing, June 2, 1982.

research programs. The felicitous combination of intellectual stimulation and renewal provided by the Berkeley campus together with the capability to undertake major interdisciplinary research projects has allowed Lawrence Berkeley Laboratory to achieve a uniquely distinguished research record over the years. Among its major activities are high energy physics, nuclear physics, nuclear medicine, materials science, chemistry, energy efficient building research, and nuclear waste isolation research.

Figure 1 shows the manpower levels at Lawrence Berkeley Laboratory over the last two decades. The dynamic range of 1000 compared to a mean value of 2500 is too large for supporting a stable research program with maximum efficiency, and is also inconsistent with the career patterns of scientists. The decrease from 1968 to 1973 was part of a general decline in support of U.S. science, and similar declines are documented in the histories of other national laboratories. The relatively rapid increase in the late 1970's following the oil embargo is illustrative of the ability of national laboratories to respond to national emergencies. This rapid growth was carried out at great cost to the laboratory, and under great pressure from the Department of Energy.

In the summer of 1980, during the final months of the Carter Administration, it was already clear that U.S. science

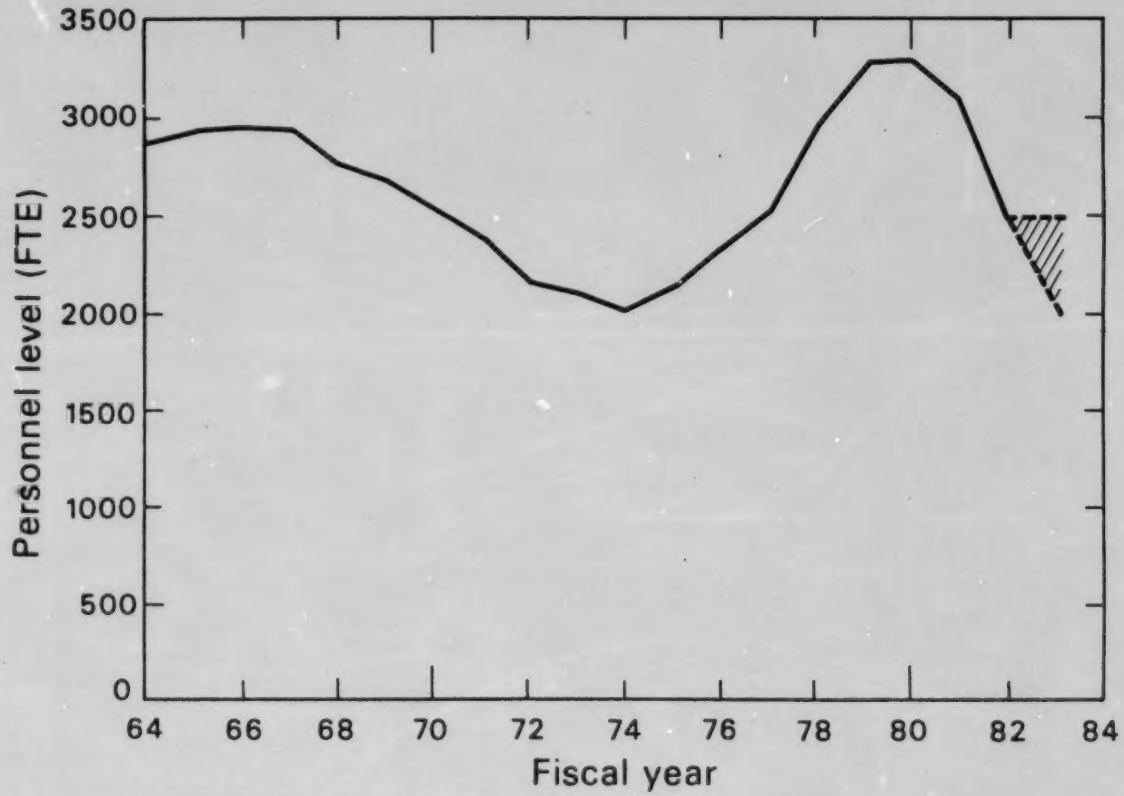

Figure 1. Personnel levels at Lawrence Berkeley Laboratory, 1964 - 1983.
Source: Lawrence Berkeley Laboratory.

was headed for another austerity period. On March 10, 1981, the Reagan Administration submitted its first FY 1982 budget. This budget expressed very clearly the new philosophy of the new administration. Defense research was to be strongly supported, as was research in nuclear energy. Other basic research would be supported at approximately a constant dollar level. Excised or reduced in the new budget were activities in other energy technologies, particularly those involving development and demonstration, which were felt to be the prerogatives of the private sector.

The instructions were clear, and the laboratories had nearly six months to consolidate in preparation for FY 1982. At Lawrence Berkeley Laboratory this entailed a reduction in force of approximately 300 people, or 10 percent of our work force. An adjustment of this magnitude is within the dynamic range of a national laboratory, and the changes were carried out smoothly.

On September 24, 1981, a revised administration budget was issued in which 12 percent cuts were allocated to most domestic programs. Of course, a sudden cut of this magnitude sent shock waves through domestic programs, including those of the scientific community. Because the cut was announced immediately before the beginning of the fiscal year, long after most planning and commitments for scientific programs had already been irreversibly made, the proposed 12 percent reduction had a very disruptive effect indeed. In the final analysis, the 12 percent cut was actually ameliorated by approximately a factor of two through redistribution of cuts within domestic programs and through Congressional action, and some agencies were treated quite differently than others.

The short-term effect was most severe at the national laboratories, where management was faced with the choice of paring its work force by a substantial amount immediately, or of taking a chance and waiting, with a possible consequence of having to pare its work force to a much greater extent later. Among the national laboratories, Lawrence Berkeley Laboratory was most severely affected. We were forced to reduce our staff by another 300 employees, bringing the total reduction to 600 -- approximately 19 percent of our initial work force.

It is important to note that this reduction at Lawrence Berkeley Laboratory was not the result of a peer review process or, indeed, of any rational process. It was simply the consequence of the particular distribution of DOE programs which the laboratory was conducting. About 70 percent of these programs were in the basic research area, and approximately 30 percent were in the areas of energy

technology. The former was reduced slightly, and the latter reduced severely. These same programs suffered similar fates in other laboratories, but in most other laboratories the total impact was ameliorated by the presence of programs in weapons research or nuclear energy.

It may be useful to point out at this juncture that the national laboratories serve as something of a bellwether for domestic scientific programs because of their institutional structure. Thus, while it was necessary for Lawrence Berkeley Laboratory to respond to the proposed 12 percent cuts within approximately six days, reducing its work force and scientific programs immediately, in other institutions supported by grants and contracts from other agencies the impact will be felt over the next two or three years as grants come up for renewal. Because it is the nature of federal programs to build each year on the base of the previous year, the long-term effect of the September 1981 reduction is unmistakable: it is a downward renormalization of the total federally-supported nondefense R&D effort in this country.

Now we are experiencing the third wave of proposed program reductions since March 1981. In a sense this one is the most disruptive of all. In the first cuts, in March 1981, it was quite clear what the laboratories had to do. The new administration had expressed its philosophy and selective reductions were necessary. The second cuts, in September 1981, were quite unselective and of somewhat uncertain magnitude, but again it was clear that across-the-board cuts had to be made.

As we now look ahead to the FY 1983 budget, we see unprecedented uncertainty. We know that substantial cuts will be necessary, but we do not know their magnitude, nor do we as yet know in what areas the cuts will be necessary because of the substantial difference in administration and Congressional intentions. Another 20 percent reduction in force would be required at our laboratory to fit the administration budget. At the other extreme, a continuing resolution (which at this time is regarded as rather likely) would imply a much smaller reduction in staff, in somewhat different areas, and one which could be dealt with in large measure by attrition.

Let me now briefly comment on some more general issues that fall within the purview of this symposium.

First, we must reach concurrence on the role of our national laboratories. These laboratories comprise a great national asset, but their proper role in the context of national needs of the 1980's and 1990's has not yet been

clearly defined. For historical reasons they were created under the aegis of the Atomic Energy Commission and have been inherited by the Department of Energy; nevertheless, they are in every sense of the word our real national laboratories. In 1982 it should not be necessary to justify the existence of such research institutions; their necessity has been proved repeatedly during the last 50 years.

To state the case briefly, a society based on high technology requires research and development laboratories in which large interdisciplinary teams of scientists and engineers can address problems related to national needs. Neither universities nor industry can fill this role satisfactorily. Of course, the detailed missions of national laboratories should be reviewed continuously as national needs and priorities change.

It would add greatly to the institutional health of the laboratories, and, more important, to the overall health of the U.S. scientific research program, if fundamental roles of the laboratories could be defined and agreed upon by all sectors of the scientific community, rather than being regarded as a "problem." Scientists in universities, industry, and national laboratories would then have a secure institutional context in which to conduct their real work of scientific research and development. I am pleased to note that role definition is underway through reviews of the national laboratories both by the Energy Research Advisory Board and by OSTP.

Having access to this podium, I would be remiss if I failed to address a problem of such transcendent national importance that it subsumes both the immediate question of the FY 1983 federal R&D budget and the role definition of national laboratories. This is the problem of a continuing philosophical gap between the performers of scientific research, especially in the university sector, and those in the administration and Congress who allocate resources for federally-funded R&D.

Let me digress briefly to state my credentials for addressing this topic, which would be of only indirect interest to most laboratory directors. I am basically an academic, a member of the Berkeley faculty for over twenty years, with a continuing personal involvement in research and graduate education. I have even been a department chairman. At present I serve on the Academy Committee on Government-University Relations in Support of Science (GURSS). In addition, my laboratory is embedded in an academic milieu, as described above. Thus I speak from experience of the university perspective.

Returning to the immediate problem, it is well-known that we Americans are pragmatists. Federal resources tend to be allocated to solve national problems. Witness that the four largest budget categories listed in Table 1-4 of AAAS Report VII are defense, space, health, and energy, with general science in fifth place. Given these facts, it is surprising that many university representatives do not refer more explicitly to national needs in their requests for more federal support. They tend to misread the political process, in my opinion, and to identify their support with the entitlements portion of the federal budget. On the other side of the gap, those in government who bear the responsibility of allocating resources to address national needs appear sometimes to interpret that job too narrowly, without due consideration of the institutional infrastructure needed to do the R&D work.

That these are real issues is evident: on the one hand, there exist serious national needs and national security issues which should be addressed by the best brains in the country. On the other hand, there are serious institutional needs related to the long-term support and health of our universities and other research institutions. Unfortunately, we hear very little dialogue on these real issues. Rather, the interaction is trivialized by disputes over such items as OMB Circular A-21 and the extent to which information transfer must be controlled in the interests of national security. The result is that instead of rolling up our sleeves and building America's scientific enterprise to deal with national problems together, we tend to dissipate our energies in bickering over peripheral issues.

One symptom of this phenomenon is the oft-quoted oversupply of lawyers. Another is the tendency to treat the support of scientific research as a procurement activity. More serious than either of these are the insularity of some of our major federal R&D programs, which do not make full use of the best brains available in the U.S. scientific community, and a growing decline in the real support of basic scientific research, most poignantly evident in the continuing disinterest of young people in pursuing careers in basic research.

This last fact is perhaps most alarmingly documented by Figure 2, in which I have plotted the decline in Ph.D. degrees awarded to American citizens in the physical sciences and in engineering, taken from Summary Report 1980: Doctorate Recipients from United States Universities published by the Commission on Human Resources, National Research Council. The decrease by a factor of two in Ph.D. production between 1970 and 1980 is totally inappropriate for a country that depends

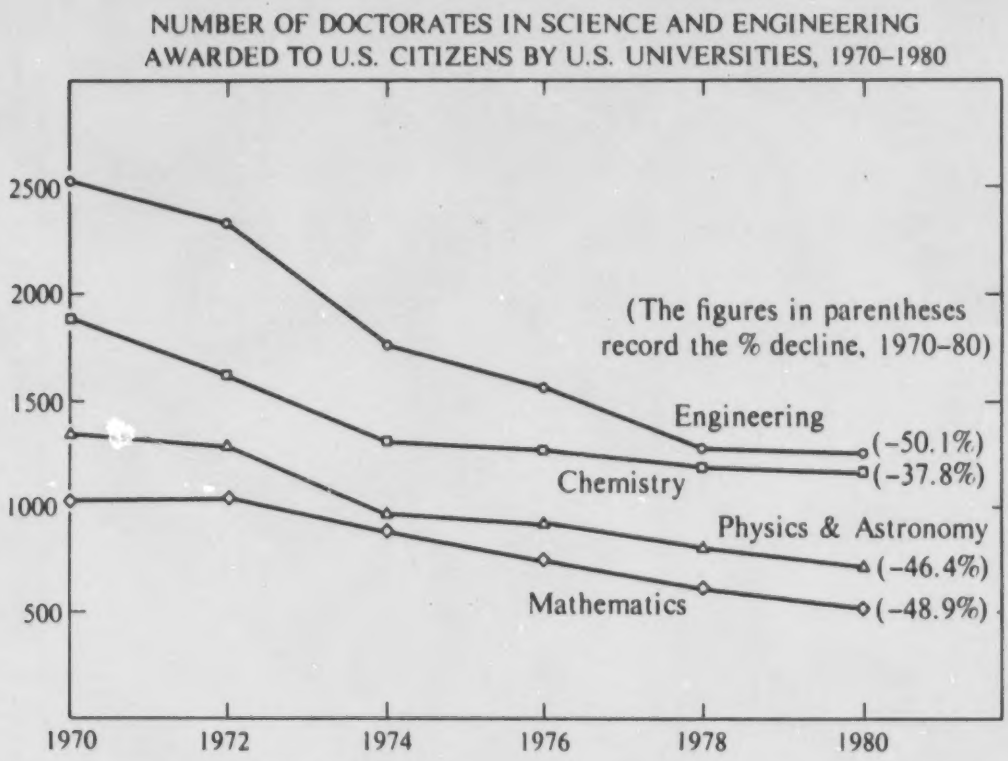

Figure 2. Decline in doctorates in science and engineering, 1970 - 1980.
Source: National Research Council, 1981.

in large measure on its high technology for world leadership. For a healthy America, and for the healthy science and technology base on which it depends, it is essential that we reach a national resolution of the issues that have led to this decline.

LUNCHEON

Presiding:
Ray Thornton *(Chairman, AAAS Committee on Science, Engineering and Public Policy; and President, Arkansas State University)*

Address:
Harrison (Jack) Schmitt *(Member, U.S. Senate)*

CONCLUDING REMARKS

William D. Carey *(Executive Officer, AAAS)*

Luncheon Address

Harrison Schmitt

The role that I see for science and technology in our future is the same role that they have played in our past: they are the reservoir of solutions to fundamental problems that afflict our society and of fundamental opportunities that are presented to it. In that context, we are again in an extremely critical time for the United States with respect to science and technology.

The dominant position which we have held throughout our history, which we have enjoyed for commercial as well as national security purposes, went relatively unchallenged through World War II and on into the 1970s. But, unrecognized by us, a number of forces were taking effect. Many nations, not just our adversaries, but also our economic competitors, were targeting major areas of science and technology for emphasis.

In addition, we let our own science and technology base wither, or at least be rejuvenated at a much slower rate than had been previously the case. The relationships among industry, universities and government became unbalanced in many different ways. The importance of the human resource, the human capital, for all of these elements of our science and technology base was unrecognized for a variety of reasons. And federal responsibilities for research and development became confused. The present time is important because all of these factors must be reexamined, reassessed and changed. We cannot afford to let these adverse trends continue.

In my various committee assignments in the U.S. Senate, I have tried to position myself so that I could be particularly helpful in the federal role relative to science and technology. As you know, I am chairman of the Science, Technology, and Space Subcommittee of Commerce, and there we oversee a number of programs, including those of NASA, NOAA, and the National Bureau of Standards. We also have some joint responsibility for the National Science Foundation authorization. I am chairman of the Appropriations

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Subcommittee on Labor, Health and Human Services and Education. And in that, of course, we oversee the National Institutes of Health appropriations bill. I am a member of the HUD-Independent Agencies Appropriations Subcommittee, where a number of agencies, including the EPA, are considered. In addition, I am a member of the Appropriations Subcommittees on Defense, on Interior, on Energy and Water Resources -- all of which oversee a considerable portion of our science and technology base. In addition I have just recently and temporarily joined the Governmental Affairs Committee, in order to participate in the discussion of the Federal Energy Reorganization Act of 1982.

Through all of this I have tried to develop a coherent view of the research, technology and development activities of the federal government. We are a long way from having that coherent view. (When I say we, I mean those of us who are assisting in that process.)

One effort that I hope will reach preliminary fruition this year is the development of a comprehensive research and technology or science and technology budget for the federal government. That is a much more difficult job than I thought when I asked my staff to look into it to see if it were feasible. The Office of Management and Budget does not have such a comprehensive view of what's happening in the federal government relative to science and technology. I think it's time that at least the Congress had such a view. We are working very hard to establish that, working with organizations such as the AAAS and many others who make their own efforts to develop such a comprehensive overview.

But rebalancing the research and development relationships between industry, government and universities is an extremely important goal for this government of ours. There has been an overdependence of universities on government since the Sputnik and health research boom in the early 1950s. So much good came out of that -- practically the only bad that came out of it was a much greater dependence on government funds than ever existed before.

Industry has a responsibility to support more education and research in science and engineering, as the primary user of the people and the ideas that are produced from that support. Unfortunately, it is only in the last year or so that we have seen a rejuvenation of industrial interest in this area. The problem is absolutely mind-boggling.

In the university system we not only are seeing the best of the baccalaureate degree holders hired away

instantaneously by industry and by government, without going into the advanced degree stream, but we are seeing the best of the young faculty hired away by the same entities, particularly by industry. I've referred to that as eating your seed corn and shooting your farmers on other occasions, and although I may be exaggerating to some degree, the analogy, I still think, is valid.

At the same time, the tractors in the university system are rusty and obsolete -- that is, the research equipment and facilities necessary for the training of young people and for the production of good quality research are well behind the state of the art in industry, both here and abroad. The shortage of support for students and faculty members, particularly young faculty members, has reached crisis proportions.

Fortunately, everybody realizes now that this problem is far in excess of what any one sector of our society can deal with. Government cannot solve it all, industry cannot solve it all, certainly academia cannot solve it all. Industry in particular is, I hope, now moving quickly and forcefully to begin to rebuild relationships that were lost in the past, or to create ones that never existed. Faculty consultantships are starting to become more common. Industrial affiliates programs are an extremely important part of this process. Research consortia in which several companies join together to try, within the antitrust laws, to do things jointly, are important

I just had a conversation this morning with the President's science adviser, Jay Keyworth, about how far aggregation within certain industries can go for research and development and educational purposes without violating antitrust laws or, if necessary, what changes in those laws must be made in order to prevent further disaggregation of activity.

There is a great deal of enlightened philanthropy under way. An Exxon Education Foundation program established last year will provide $15 million for 100 teaching fellowships and 100 salary grants for junior engineering faculty at 66 U.S. colleges and universities. The Edwin C. Whitehead Gift to M.I.T. represents a $7.5 million outright gift, as well as $120 million for the Whitehead Institute for Biological Research, to be headed by M.I.T. Nobel Laureate David Baltimore. There are university and industry partnerships -- Monsanto has been a leader in this, beginning at Harvard in 1974 and now extending to the Rockefeller University and Washington University.

The University of California at Berkeley and Stanford, in the new enterprise Engenics, Inc., represents a $7.5 million investment from six major corporations. University research funding is provided through a non-profit center for biotechnology research which will have a 30 percent equity position in Engenics. The center's share of dividends and capital appreciation will go back into research at the two universities.

So there are things happening, these are extraordinarily healthy trends. But they are not nearly enough. As you know, the prevailing estimates of the shortfall of young advanced degree holders in science and engineering is approaching, if not crisis proportions, proportions which, if they go unchecked, will soon be crisis in nature. The minimum estimates are an annual shortfall of ten thousand advanced degree holders; the maximum estimates, particularly those by the Department of Defense, are closer to fifty thousand.

All you have to do is look at your own universities, and you see that almost half of the persons in the advanced degree stream are foreign nationals. They are not American citizens. The government should induce as much private sector response as it possibly can, and some significant steps have been made by Congress and the administration. For example, the Economic Recovery Tax Act of 1981 provided a 25 percent credit for incremental R&D investment, accelerated depreciation for research equipment, and a liberalized credit for donations of research equipment to universities -- tremendous incentives.

In my own Subcommittee on Science, Technology and Space, we have reported out a bill which will take the form of amendments to be offered to the NSF FY 1983 authorization, that would add $10 million for university-industry cooperative programs. We have been led to believe by testimony from the private sector that this will generate of the order of $20 million in private sector support for equipment, fellowships, and research projects in science and engineering education.

Probably there is no more critical task before you, before me and before the Congress right now for the long-term health of science and technology in this country than rebuilding the quality and the size of our science and engineering manpower pool. We must begin to view people as a necessary raw material, a necessary resource, for the health and vitality, not only of our private sector, but of our public sector and of our national defense.

The declining science and math emphasis at the pre-college level probably is the root of our problem, but is

not our only problem. There clearly are shortages of science and mathematics graduates from teachers' colleges, and those that are graduated are generally considered to be underqualified for the jobs that they have volunteered to take. There is a deficiency of scientific and engineering faculty, in some critical areas. Shortages of engineers occur seemingly across the board, but in some special areas such as computer engineering and computer science, an absolute crisis has developed.

Most attention has been directed to the students that are in the university and secondary school levels. But my own feeling is that while we direct efforts towards the college, university and graduate degree levels, we must also remember that all the way down in the pre-school area, in the 1 to 5 and 6-year-old student, there is an environment that is extraordinarily non-conducive to science and mathematics education in the future.

Pre-school education of young people today is primarily a function of commercial television. It has ceased to be a function of the family to the degree that you and I would hope. Now, I think that video programming is a tremendous opportunity for education of pre-school as well as other students. But we have not even come close to realizing its potential.

Somehow, video programming has become interactive. When I talk to parents about this problem, I find very frequently they will refer to "Mr. Rogers" as the kind of program that they enjoy having their children watch. For some reason, that programming is capable of eliciting a reaction from the child. Many parents have told me that the child talks to the television set, which is exactly the response you want to get. You want to get the mind interacting and not just being a passive absorber of information.

Those of us who grew up with books and are old enough to remember radio may have had a distinct advantage. I know my father didn't think so; he limited me to one half hour of radio every night. He didn't want me listening to blood and thunder and that kind of thing. We think of blood and thunder as a television problem now, but I remember my father, back in the forties, worrying about that on radio. And believe me, we were capable of cheating on him, just like your kids cheat on you. I remember, I built a crystal set -- as a geologist and an engineer it was beyond my father's capacity to forbid my constructing a crystal set -- which I would go to sleep listening to through my headphones. I would wake up in the morning with my mother standing over me saying, "Don't blame me if you choke to death."

More seriously, of course, is the question of how do we deal with this problem? And I would add as a footnote that I am extremely gratified that the Corporation for Public Broadcasting has put children's programming at the top of its priority list. I think by so doing, it not only begins to move more aggressively into an absolutely essential field -- leading the state of the art in children's programming, where it should have been for a long time -- but it's going to be able to generate far greater congressional support than it has in the past few years. The Corporation has been losing congressional support; I do believe that if it does that job sincerely and well, that support will return.

The federal government has an important responsibility in this area. The NSB's Commission on Pre-College Education in Mathematics, Science and Technology is an important adjunct to that effort. It is unclear what will happen with respect to that commission, as a consequence of John Slaughter's departure but I think that it will continue, and continue to do a great deal. Enough is already known to take steps before the Commission's formal recommendations are due.

The discussions that many of us had a few weeks ago at the National Academy of Sciences under the guidance of Frank Press were very helpful in this area. And I hope they will continue to play an essential role in stimulating discussions of science and mathematics education.

We plan to introduce legislation which will address some of these and other problems. In particular we want to address the problem of college and university young faculty in science and engineering we want to improve the instructional skills and knowledge of elementary and secondary teachers in science and mathematics; and we want to stimulate even further private sector cooperative support of educational problems. We will be happy to share that legislation with you, even in draft form, as soon as it's ready, for your comments; we feel that it is very important that we begin to provide some kind of substantive focus to this problem. There are other bills around which are really very cosmetic in what they're trying to do -- I should not say this, but they are really political documents rather than attempts to get at generic solutions.

It is also important to improve the rate and character of transfer of the results of research and technology development supported by the federal government. The federal government supports something on the order of $35 billion annually, of what is designated R&D, about one half of the estimated national investment. Again, one reason we want this unified and detailed budget is to find out what is really being invested.

The transfer of the results of this research and development into new goods and services for the people of this country has, by my estimation, been largely insufficient and ineffective. What has happened has sometimes been significant, even remarkable, but it has happened in spite of the federal government instead of because of the federal government.

Years ago our moderator, then Congressman Thornton, began an effort to develop a uniform patent policy for the federal government. You may be surprised to know, or if you have dealt with the federal government agencies you already know, there is no uniform patent policy in the federal government. Every agency has a different set of rules and beliefs on how that should be conducted.

After years of work and groundlaying, beginning with Congressman Thornton, a number of us on both sides of the House, including Congressman Ertel and myself in the Senate, are moving steadily towards the enactment of a uniform patent policy. A major milestone was passed two years ago with the passage of Public Law 96-517, the so-called Bayh-Dole bill which applies to small business and university contractors. The current legislation on the Senate side, S.1657, has been reported out of the Commerce Committee, is on the calendar, and is almost ready for Senate action. The bill guarantees federal contractors and grantees a first right of refusal to title to their inventions, extending the provisions of the Bayh-Dole bill.

The most important thought I want to leave you with is that this is not a problem that is going to go away. At least it won't go away until we put our hearts and minds and resources to solving it. Science and technology have been the strength of this country; the major milestones for which history recognizes us are the applications of science and technology. It's difficult to name one milestone that doesn't have its roots in our ability to reach into a pool, a reservoir of science and technology that was created by free men and women working within a free society and then applying that reservoir to solve problems. We can continue to do that; as a matter of fact I enjoy challenging crowds to name one major domestic problem that we face that isn't going to require an application of the science and technology base, either current or future, before we have a solution. I believe in that.

We are trying to do everything we can to develop the capability to reach for those solutions as well as encourage this administration, like all other administrations, to try to develop some science and technology policy in a wide variety

of areas. It is very difficult for people who do not have background and experience in science and technology to look for solutions to problems that involve some risk in the use of science and technology.

It's just human nature -- you reach for solutions from your own experience base -- and it's difficult for policymakers who do not have this experience base in science and technology to really place confidence in what science and technology can do. What this organization must do, and what all others must do, is continue to plug away to try to build that level of confidence, to get into government, to work with government, as competently and objectively as possible. That confidence level must grow so we can solve some fundamental problems, that if they go unsolved, almost certainly will result in a tremendous loss of freedom in this country and a tremendous decrease in the well-being of our citizens.

Concluding Remarks

William D. Carey

Before I offer my conclusions about what's been going on here for the last day and a half, I have a brief parish announcement. In 1983, the AAAS Annual Meeting will occur, not in the wintry days of January, but in late May; it will be scheduled in late May for the next several years.

We're planning to hold the Colloquium on R&D Policy in March and base it on the Intersociety Preliminary Analysis of the budget -- known colloquially as the "Early Bird." We hit the streets on the heels of the President's budget; it's only possible to do this with the cooperation of some 16 of our affiliated societies, working with our staff, and it's done very fast. It's turned out to be exceedingly useful, I'm told, to people on the Hill.

When we get to the AAAS Annual Meeting at the end of May, we also will have the R&D book completed. The present plan is to hold a one-day symposium in Detroit, on the state of U.S. budget policy.

Let me turn now to my concluding remarks. I've sat through the past day and a half, and I've gotten a good deal out of it. We're very fortunate to have had the quality of discussion that has gone on. We've been trying to eye the several environments that affect science and technology in the United States: the public policy environment, the academic environment, the industrial environment. I tend to reach the predictable conclusion that all three environments are volatile at this point in time, and that the public policy environment is driven less by explicit R&D policy requirements than by a combination of fiscal policy goals together with a reformation of national priorities. Those are political facts of life and we are within a political framework.

For those of us who yearn for a long-term, strategic approach to science and technology policy, because continuities do matter in advancing science and technology, it's a little hard to be heard above the noise of budgetary

feuding and ideological confrontation. It begins to seem, more and more, that as all this quarreling goes on we are not a unified nation, but a very seriously divided one: divided on the merits of economic strategies, national security strategies and domestic equity strategies. To call this American pluralism is perhaps to give it a better name than it deserves, because we are close, as I said in a recent editorial, to having deadlocked policymaking machinery, and that is very troublesome. It's a larger issue and a larger problem than what may happen to research and development.

To say that there is not enough money for R&D is not realistic; there's a lot of money for R&D. The numbers, taking both the private sector and the government sector this year, indicate something like an $80 billion outlay, and I have said several times that over the decade of the eighties there will be roughly a trillion dollars spent in the U.S. economy on R&D. The question is are those real dollars or are they only partial dollars, and that question has been raised here today both at this podium, and in some private conversations. I think that we need to examine very closely what the so-called R&D dollar consists of, and how much of it ever gets to the bench.

But the numbers <u>are</u> impressive. They are very, very large. Still, if the result of all this R&D input is to jam the pipelines with research that doesn't get drawn out into innovation, then we are going to strand research results on the sidings of the national economy while we watch competing economies whiz past on the main line. If defense R&D balloons with increases, such as I've heard, of up to 50 percent over the next few years while non-defense R&D falls by 30-40 percent as federal allocations decrease, then I think our deferred investment will be growing too large to overtake when things get better. If nearly all of our national R&D effort is focused on our own needs, to the continued exclusion of Third World needs, then we're going to lose the opportunity to use science and technology in building political assets that we will need very badly in the next decade and after the next decade. If we exaggerate the problem of outflow of scientific and technological know-how from the U.S. and jump in with crippling governmental restrictions and censorship of the circulation of unclassified research, we'll shoot ourselves in the foot.

Fiscal policy, indeed, is very important, but it's not infallible, as we have come to see. We talk about uncertainty in science; there's plenty of uncertainty, if not more, in economics, while global security is more complex than the size of the U.S. defense budget, and neither science

nor technology can be counted on, in my view, to pull our chestnuts out of the fire when the political machinery runs out of options.

It isn't my job to try to recapitulate all that we have heard yesterday and today. A few things stood out, however: the administration may be adamant against funding technological development, with the notable exceptions of nuclear technology and weapons, but there's no question, in my opinion, about its commitment to the support of basic science and the growth of basic science. And I'm impelled to say that while OMB is a very convenient whipping boy in all of these matters, I happen to know some things that you don't know and one of them is that the people in OMB deserve a tremendous amount of credit for encouraging and fighting for basic science. I see Hugh Loweth of OMB down there at the end of the room, and someday, someday I hope that science will thank him.

I think the administration has yet to be convinced that the state of pre-college science and math education is a federal question -- we are going to have to work on that. I gather that the administration is beginning to convince itself that Japan, Inc. is in the process of withering away, which is certainly an imaginative thought.

I sense that the administration sees a break in the clouds in the shape of sharply rising industry R&D expenditures, to which I say maybe, and then again, maybe not. What struck me is that most of the discussion bore on the internal difficulties of the U.S. economy, and our science and technology infrastructure, with next to no mention of international scientific cooperation. I think that's a pity.

And then we did get from Senator Tsongas last night the advice, in his words, that science shouldn't complain when things go wrong for it at the hands of government, because the truth is, he said, that science prefers to be apolitical in a system that rewards political skills. This wasn't the first time this advice had been given at one of these colloquia -- some of you will remember that Congressman Giaimo made the same point two or three years ago. Mike Telson's scary prophecies for the coming five years, if they are as perceptive as I suspect they are, suggest to me that the low grade Senator Tsongas gave to the politics of science calls for some soul-searching. And I must say that I am indebted to Dave Shirley for the elegant expression he uses in referring to what's been happening to the federal R&D budget -- he speaks of it, as you remember, as a "downward

renormalization." I can't wait to get that into an editorial in Science.

Nothing that I've heard in the Colloquium changes my own belief that the architecture of the United States R&D system is headed for real changes as resources continue to tighten up. I don't know what the form of those changes will be, but I can make some guesses. I think the priorities for federal support, whether that support comes in terms of appropriated dollars or in terms of the back-door way of tax expenditures, that the benefits will go to basic science in the first-ranked universities, to industrial research and development, and to national security-oriented organizations and goals. Some things are going to have to give, within the present post-war architecture of science and technology. There are going to be some costs.

Frank Press, in his remarks yesterday, alluded to some changes that he suspected would be needed. He suggested that there still is -- he didn't use the word fat -- but in effect he thought that there was room, even within our present arrangements and funding, for some restructuring and some redirection and redistribution of resources. That is a very large and very incendiary kind of problem, which it seems to me, we should be trying to address with lead time, instead of getting into a shoving contest somewhere down the road.

If there's slack in our R&D potential -- and I tend to think the system is being run and operated, at best, at half to two-thirds of its capacity -- then the policy question is whether such idle capacity in our scientific and technical resources is good for the country and its future, and whether anybody really cares, and I think that there are a lot of people who do. What's clear also, I think, is the dependence of science and engineering on the performance and the foresight of our institutions, all the way from the White House and the Congress to the market economy, right down to the school boards.

We have been talking about the FY 1983 budget. I can tell you that nothing becomes obsolete faster than a prior fiscal year. And the 1983 fiscal year is not going to be any exception. The drama of FY 1983 may be high and the risks real enough, but it's still only a chapter in an unfolding story, a suspense story. Yet bear in mind that in each fiscal year we take one more step, we set a trend in place, we trade off on choices and we influence what is yet to come. That's what we must understand and that's why a Colloquium like this has more than a casual significance.

About the Speakers

Daniel D. Adams

Daniel D. Adams is the founder, chairman, and chief executive officer of Advanced Genetic Sciences, Inc. a research and development company formed in 1979, which is applying advanced microbiological techniques to the improvement of agronomic plants and plant biosystems.

Adams earned a B.A. in chemistry from Cornell Univesity and a J.D. from New York University School of Law. After five years of practicing law with the New York City firm of Sullivan and Cromwell, he founded and directed the venture capital activity at International Nickel Limited. Early in the life of that venture capital fund, Adams became interested in genetic engineering and made investments in Cetus and Genentech, resulting in one of the best performance records achieved by a venture capital fund. Adams also helped conceive and organize Biogen, S.A., the first European biotechnology company.

Robert F. Allnutt

Robert F. Allnutt is acting associate administrator for external relations at the National Aeronautics and Space Administration, a position he has held three times during his current tour at NASA. He became NASA's deputy general counsel for policy review in late 1981. He came to NASA from the Department of Energy, where he had been assistant general counsel for legislation.

A native of Richmond, Virginia, Allnutt graduated from Virginia Polytechnic Institute with a degree in engineering. He received his J.D. (with distinction) and Master of Laws degree from George Washington University Law School. From

1957 to 1970, Allnutt served in the U.S. Patent Office as an attorney for the Communications Satellite Corporation, and at NASA as patent attorney, as assistant general counsel, and assistant administrator for legislative affairs. In 1970 he was named associate general counsel for the Commission on Government Procurement. In 1973 Allnutt became staff director of the Senate Committee on Aeronautical and Space Sciences.

Arden L. Bement, Jr.

Arden L. Bement, Jr. was appointed vice president for technical resources at TRW, Inc. at its headquarters in Cleveland, Ohio, in January, 1981. In this position he identifies and evaluates emerging technologies and recommends product, material, and process development projects. He also develops special relationships with selected universities and helps recruit key individuals in new technologies of interest to TRW.

A native of New Castle, Pennsylvania, Bement received an engineer of metallurgy degree in 1954 from the Colorado School of Mines. He received an M.S. in metallurgical engineering from the University of Idaho in 1959 and a Ph.D. from the University of Michigan in 1963. After experience with G.E. at Hanford, Washington and Battelle in Columbus, Ohio, in 1970, Bement joined the faculty of M.I.T. as professor of nuclear materials.

In 1976 Bement became director of the materials sciences office of the Defense Advanced Research Projects Agency and in 1979 was appointed deputy under secretary of defense for research and engineering, serving with Dr. William Perry; it is from that post that he went to TRW.

Dimitri V. D'Arbeloff

Dimitri V. D'Arbeloff, chairman and chief executive officer of Millipore Corporation, joined the firm in 1962. Millipore manufactures and markets products and systems for the analysis and purification of fluids. Active in a variety of organizations, he is chairman of the Massachusetts High Technology Council, a trustee of Johns Hopkins University, and past chairman of the Health Industry Manufacturers Association. He is a director of Millipore Corporation, Cambridge Trust Company, Loctite Corporation, Black and Decker Manufacturing Company, Health Industry Manufacturers Association, the Massachusetts General Hospital and the American Business Conference in Washington. He is a graduate of Harvard College and the Harvard University School of Business Administration and served in the U.S. Navy.

Martin Goland

Martin Goland received his M.E. (summa cum laude) from Cornell University in 1940. He also holds an honorary degree (L.L.D.) from St. Mary's University. Goland served as an instructor at Cornell University and worked as an engineer for Curtiss-Wright Corporation and Midwest Research Institute before joining the Southwest Research Institute in 1955. He became president of SWRI in 1959, and has held that position since that date. Goland is involved in numerous professional and civic activities, including serving as a member of the Governor's Texas Aerospace and National Defense Technology Development Council, the Governor's Council on Career Education and the San Antonio Council on Engineering Education. He is chairman of the NASA Aeronautics Advisory Panel Committee on Materials and Structures. Goland is past president of the American Institute of Aeronautics and Astronautics, a member of the National Academy of Engineering, and a fellow of the AAAS.

Margaret M. Heckler

Congresswoman Margaret M. Heckler received her B.A. from Albertus Magnus College in 1953 and her LL.B. in 1956 from Boston College. She also has nine honorary degrees. In 1956 she was admitted to the Massachusetts Bar, and also to the U.S. Supreme Court. She has served as a member of the 90th to 97th Congresses. Heckler is a member of the Joint Economic Committee, the Committee on Veteran's Affairs, and the Committee on Science and Technology, where she is ranking minority member on the Subcommittee on Science, Research and Technology. She is also co-chairman of the Congressional Woman's Caucus. Heckler served as a member of the Massachusetts Governor's Council from 1962 to 1966 and as a delegate to the Republican National Convention in 1968, 1972, and 1980.

George A. Keyworth, II

George A. Keyworth II came to the post of science adviser with strong credentials in the field of physics and laboratory administration. With a B.S. from Yale and a Ph.D. in physics from Duke University in 1968, Keyworth joined the staff of Los Alamos Scientific Laboratory to conduct research in neutron physics. In 1974 Keyworth undertook efforts to strengthen the Los Alamos programs in basic experimental science and to develop a comprehensive and imaginative program in weapons physics. In 1980 he was appointed as acting division leader of the Los Alamos Laser Fusion Division. When the division was combined with the Physics Division in 1981, he was made

leader of that Division. Keyworth has authored many important scientific papers.

Frederick N. Khedouri

Frederick N. Khedouri is associate director for Natural Resources, Energy and Science in the Office of Management and Budget. He is responsible for matters relating to the Departments of Agriculture, Energy, and the Interior, the National Aeronautics and Space Administration, the Environmental Protection Agency, the Army Corps of Engineers (civil), the National Science Foundation, the Smithsonian Institution, and a number of small agencies. Prior to joining OMB in January 1981, Khedouri served on the Presidential transition team. From 1977 to 1981, Khedouri was legislative director for Representative David A. Stockman. Born in New York City, Khedouri received his education at the University of Chicago and the University of Texas School of Law. He is a member of the State Bar of Texas.

Thomas E. Malone

Thomas E. Malone was named deputy director of the National Institutes of Health in 1977. His career at NIH goes back to 1962. Malone received his B.S. and M.S. degrees from North Carolina Central University and his Ph.D. from Howard University. He was a professor of zoology at North Carolina Central, spent a year as a resident research associate at Argonne National Laboratory, then served on the faculty at Loyola University until joining the National Institutes of Health. He is a member of numerous professional organizations in the fields of health research and administration.

James M. McCullough

James M. McCullough is deputy director of the National Science Foundation's Office of Planning and Resources Management (OPRM). His office works with the director and assistant directors of NSF to formulate long-range plans, to prepare budget [illegible]or the Office of Management and Budget (OMB) and Congress, to gain Presidential and Congressional approval of budget levels, and to oversee the spending of approved budgets. OPRM staff also serve as executive secretaries to National Science Board committees, and coordinate Foundation-wide preparation of policy options papers for the director and the Board. McCullough has been with NSF almost four years. Prior to that he was with OMB as examiner of the

NSF budget, and before that was employed by the National Security Agency as an intelligence analyst. He has a master's degree in public administration.

Frank Press

Frank Press was elected president of the National Academy of Sciences in July 1981, continuing a distinguished and varied career in science and public service. He served as science adviser to the President and director of the Office of Science and Technology Policy during the Carter Administration. Prior to that time he served for over a decade at the Massachusetts Institute of Technology as professor of geophysics and chairman of the department of earth and planetary sciences. He has also taught at the California Institute of Technology and Columbia University. Press received his Ph.D. from Columbia University.

David V. Ragone

David V. Ragone received his B.S., M.S. and D.Sc. degrees in metallurgical engineering from the Massachusetts Institute of Technology. He served on the faculty at the University of Michigan until 1962, when he joined the General Atomic Division of General Dynamics. He spent three years at Carnegie-Mellon University, leaving in 1970 to become dean of the Thayer School of Engineering at Dartmouth College. Ragone returned to the University of Michigan as dean of the College of Engineering in 1972, where he remained until being named president of Case Western Reserve University in 1980.

Harrison Schmitt

Senator Harrison Schmitt received his B.S. degree from the California Institute of Technology, then studied at the University of Oslo under a Fulbright fellowship. He earned his doctorate in geology from Harvard University in 1964.

After graduating from Harvard, Schmitt spent a year working on space-related projects for the U.S. Geological Survey in Flagstaff, Arizona. He joined the NASA Apollo program in 1965. As the lunar module pilot and geologist of Apollo 17, Schmitt landed on the moon in the Valley of Taurus-Littrow in 1972.

He was appointed assistant administrator of NASA for energy programs in 1974; he resigned from this post in 1975 to

return to New Mexico and run for the Senate. In 1976 he was elected to the Senate. Schmitt now serves on the Committees on Appropriations; Banking, Housing and Urban Affairs; and Commerce, Science and Transportation; as well as the Select Committee on Intelligence. He is chairman of four Senate subcommittees including the Subcommittee on Science, Technology and Space. Schmitt is also a member of various scientific and professional organizations, and is the recipient of numerous professional and academic awards.

David A. Shirley

David A. Shirley became director of the Lawrence Berkeley Laboratory, a multiprogram national laboratory operated by the University of California for the Department of Energy, in 1980. Shirley received his B.A. from the University of Maine and his Ph.D. from the University of California at Berkeley. He joined the faculty of the department of chemistry there in 1959, becoming chairman of the department in 1971. He was appointed associate director and head of the Materials and Molecular Research Division at Lawrence Berkeley Laboratory in 1975, and held that post until his appointment as director.

Joel A. Snow

Joel A. Snow served as an instructor at the U.S. Naval Submarine School before obtaining his Ph.D. in physics from Washington University in 1967. He also taught at Washington University. In 1967 and 1968 Snow was appointed a fellow with the Center for Advanced Study, University of Illinois, and a research associate with the University's Physics Department. Snow has served with NSF in a number of policy-related positions, at OSTP as senior policy analyst, and at DOE as associate director for research policy in the Office of Energy Research. In August 1979, Snow assumed the position of senior science associate in the Office of Energy Research, Department of Energy.

Michael L. Telson

Michael L. Telson has been a professional staff member with the Committee on the Budget of the U.S. House of Representatives since 1974. As energy analyst, he has been responsible for analyzing energy programs and energy economic issues in the federal budget.

Telson holds B.S. and Ph.D. degrees in electrical engineering from the Massachusetts Institute of Technology, as

well as an M.S. in industrial management from M.I.T.'s Sloan School of Management. He has worked as a management analyst for the New York City Bureau of the Budget, and as a consultant for a variety of firms in the areas of energy, economics and the environment. In 1973-74, Telson was a AAAS Congressional Fellow with the Senate Committee on Interior and Insular Affairs.

Paul E. Tsongas

Senator Paul E. Tsongas received his B.A. in history from Dartmouth College, then served as a Peace Corps volunteer in Ethiopia for two years. Subsequently he attended Yale Law School, where he received his L.L.B. in 1967. Tsongas then returned to the Peace Corps for a year, as a training coordinator, this time in the West Indies.

Tsongas served as deputy assistant attorney general for the Commonwealth of Massachusetts and spent four years as a City Councillor in Lowell, Massachusetts, and a year as Middlesex County Commissioner. In 1975, he was elected to the U.S. House of Representatives from the fifth district of Massachusetts, and in 1978 he was elected to the Senate.

Tsongas serves on the Committee on Foreign Relations, the Committee on Energy and Natural Resources and the Committee on Small Business, where he is ranking minority member on the Subcommittee on Advocacy and the Future of Small Business. He is the author of The Road from Here: Liberalism and Realities in the 1980's.

George R. White

George R. White is corporate vice president of Research, Development and Engineering for Xerox Corporation. He has responsibility for seeing that the corporation's technical operations are integrated with overall corporate strategy.

White earned a bachelor's degree in physics from Wesleyan University, an M.S. in business administration from UCLA, and a Ph.D. in physics from Iowa State University. In 1976-77, he was a visiting professor at the Harvard School of Business Administration.

White joined Xerox in 1964 and has held a number of management positions in R&D and product planning. Prior to being named to his present position in March 1979, he was vice president of advanced development in the reprographic technology group.

Leo Young

Leo Young was appointed director for research and technical information in the Office of the Secretary of Defense in November 1981. Previously, he served as associate superintendent of the electronics technology division of the Naval Research Laboratory, which he joined in 1973.

In 1980, Young was elected president of the Institute of Electrical and Electronics Engineers (IEEE). He served as executive vice president of IEEE in 1979, and was elected four times to the IEEE Board of Directors. He has worked in industry (Westinghouse Electric Corporation, Decca Radar), was staff scientist and program manager at Stanford Research Institute, and has taught courses in the U.S. (Stanford University, George Washington University) and abroad (Leeds University, England; Technion, Haifa, Israel). Young holds his Ph.D. in electrical engineering from the Johns Hopkins University.

Appendix

Colloquium Participants

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Kathy Ausley
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University of Pennsylvania

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David Shirley
Lawrence Berkeley Laboratory

Robert Sigethy
National Defense University

Michael Simpson
Library of Congress

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